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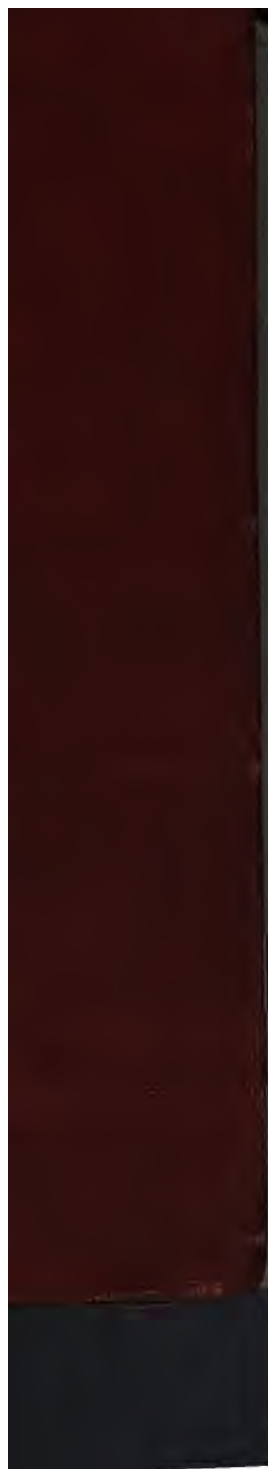
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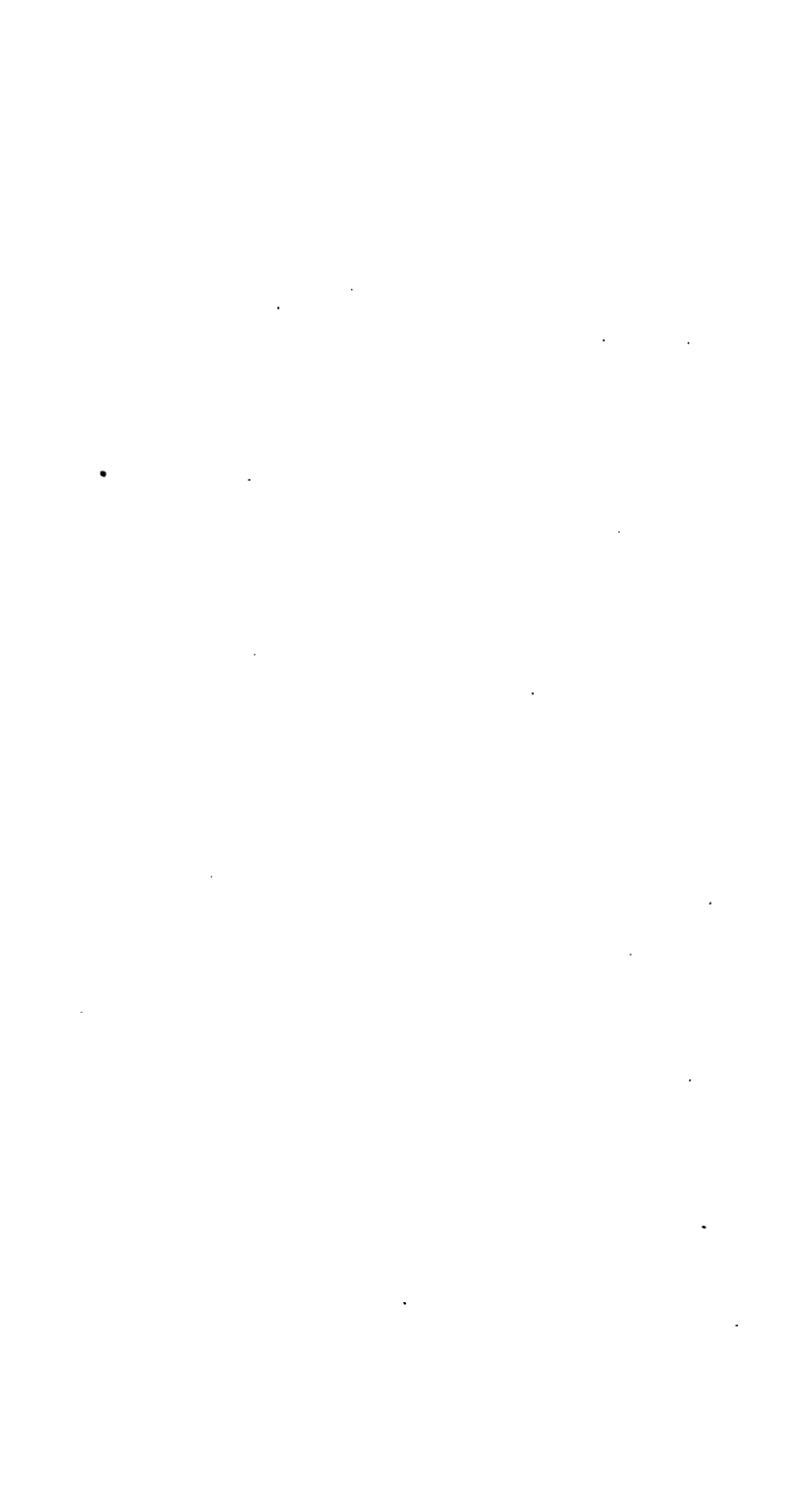
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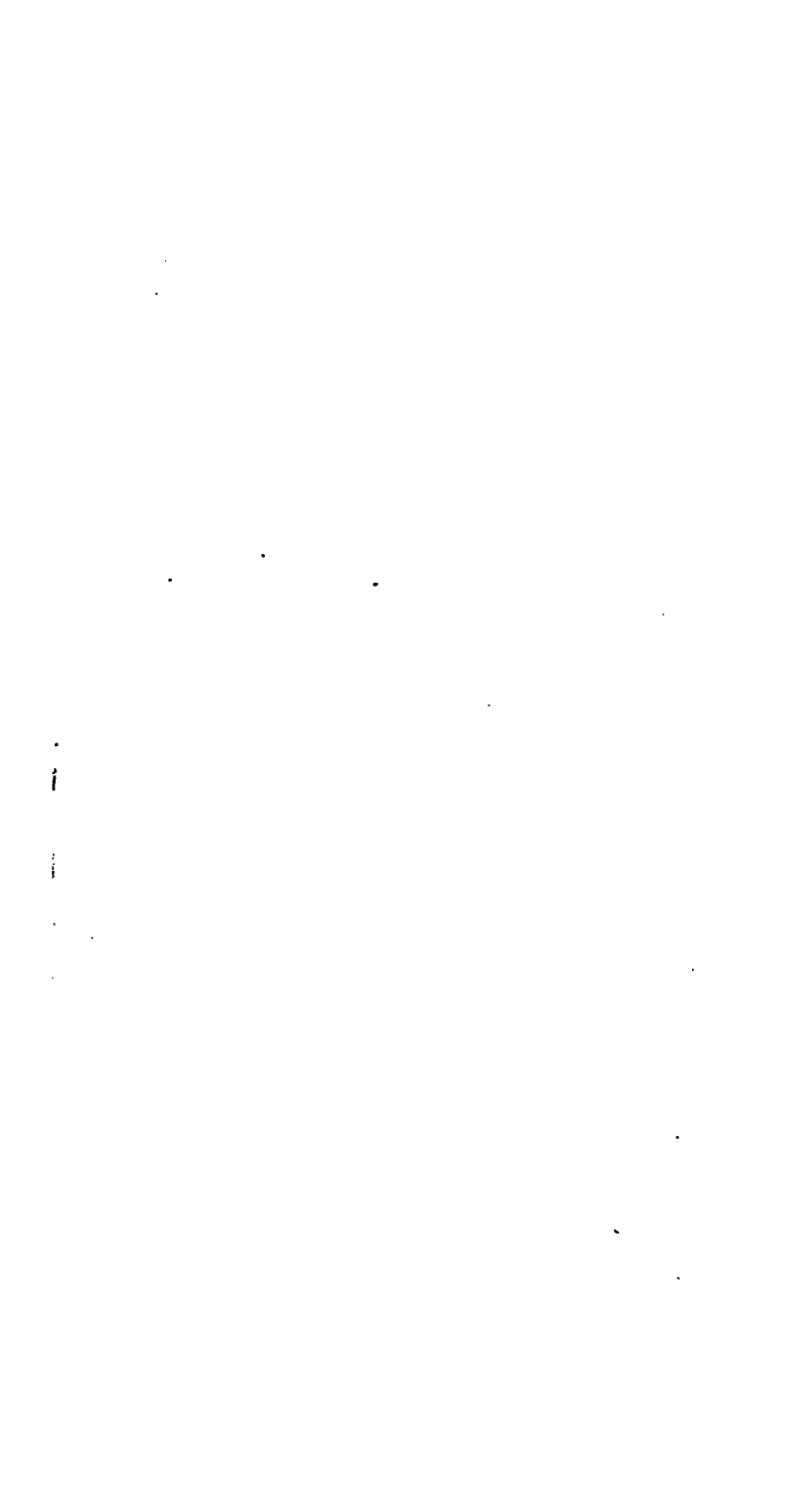








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# UNCLE ROBERT'S GEOGRAPHY

EDITED BY FRANCIS W. PARKER

IV

## A RIVER JOURNEY

BY  
FRANCIS W. PARKER  
AND  
NELLIE LATHROP HELM



**CENTRAL RESERVE**

NEW YORK

D. APPLETON AND COMPANY

1904

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## PUBLISHERS' NOTE

To account for the publication, so long after the death of Colonel Francis W. Parker, of the fourth book of the series under the title of *Uncle Robert's Geography*, some explanation seems to be necessary.

The manuscript of *A River Journey*, first sketched by Miss Nellie L. Helm, was left by Colonel Parker unfinished, but so near completion that the publishers decided to have the existing text revised and the missing chapters supplied in accordance with the plan originally outlined.

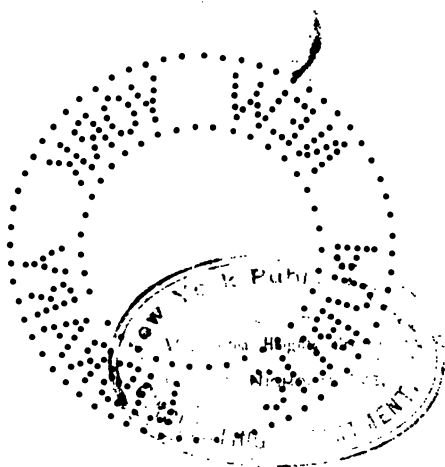
In order that the work might be kept as far as possible in harmony with the spirit of the previous work, the members of the faculty long associated with Colonel Parker were consulted, and Miss Viola Deratt, now connected with The School of Education, University of Chicago, was engaged to prepare the manuscript for publication. The result is the present volume, which will complete the series, unless arrangements should be made for the two remaining volumes projected and heretofore announced.

D. APPLETON &amp; Co.

NEW YORK, *May*, 1904.

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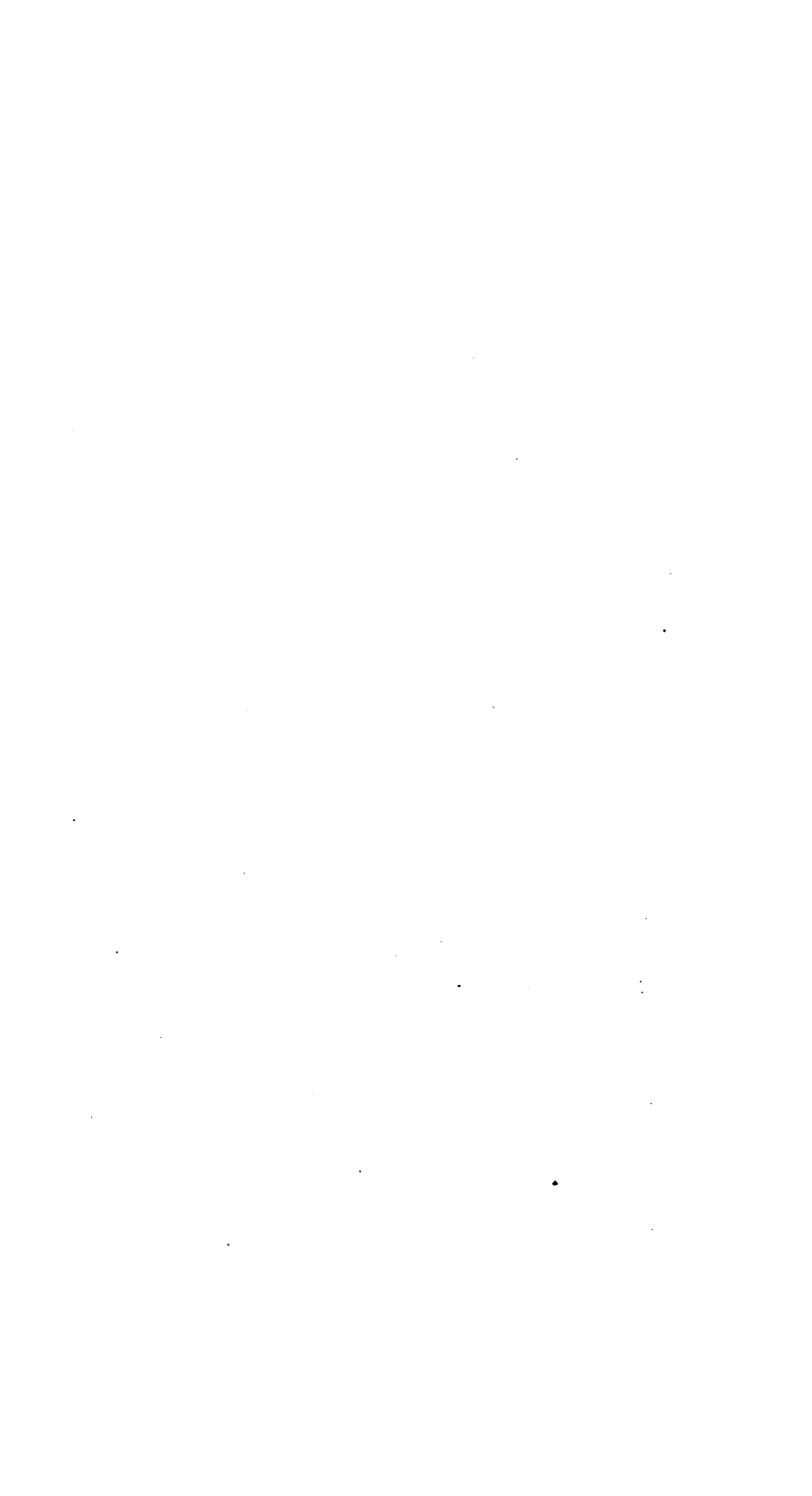
The account of the journey is continued, and the boys gather together all their facts in order to give a complete description of river action.

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## UNCLE ROBERT'S GEOGRAPHY

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### CHAPTER I

#### UNCLE ROBERT'S PLAN

THERE was a lull in the work on the farm. The barn was filled with sweet-grass and clover, a rich store of winter food. The wheat and the oats were stacked in great golden hills ready for the coming of the thrashing-machine. The cultivating and hoeing were all done. The corn on the bottom-land was filling out its rich ears. The early apples and pears were ripening. The farmers were happy in the thought of the growing crops and promise of a rich harvest.

Uncle Robert and Mrs. Leonard were seated on the piazza.

"It is wonderful, what an interest the children have in everything around them," said Mrs. Leonard. "I can see how it all came about, however. When we were children, Robert, I loved the old farm and everything that grew on it. I knew every flower and every tree. But in these days we thought the only way to learn was from books and in a school-

room. We did not know that there were better things outside of the books and outside of the school-house for children to study house."

"Yes," answered Uncle Robert, "when I was a boy I did not realize that many things I read about in my geography I could see every day out of doors."

"You have taught my children to know where to look for real pleasure in study," said Mrs. Leonard. "They have had a happy time with you, finding new meanings in the common things around them. The farm has become more beautiful to me, too, seeing it through the eyes of the children."

They looked in silence off toward the river that glistened like silver in the sunlight.

"I have a plan to propose to you, Charlotte. The boys have done good work this summer, and are greatly interested in the farm and everything that belongs to it. I think now that they should have a chance to travel a little and compare what they will see with this spot that they have studied. My plan is to take them on a river, say the Wisconsin. We could take a big boat that I have bought, you know—it is seventeen feet long—and some food, fishing-tackle, and a small tent. What do you think of it?"

"Delightful!" said Mrs. Leonard. "I should have no fear for them if they were with you."

"You may be sure I will take good care of them. We shall have a glorious time."

"But what about Susie? She will want to go."

"Yes, I know," said Uncle Robert, "but we'd

better not take her this time. She is too small to stand the fatigue, and we should worry about her if anything should happen to the boat. She is a reasonable little thing, and will be all right when I tell her how it is. I wish you would talk to William about the plan. It is best to decide it all before we tell the boys."

Just then Frank drove up from the village, where he had been to carry a load of early potatoes and blackberries which he had raised himself. His face was all aglow with pleasure. He threw down the reins, jumped out of the wagon, and shouted:

"I have enough at last!"

"Enough of what?" asked Donald, appearing around the corner of the house.

"Enough money to buy what I want. You don't know what I want, but mother and father do."

"I suppose you want a good many things," said Donald. "I do."

"But there is one thing I want more than anything else."

"Well, then, tell us what it is," said Donald, impatiently.

"A camera, so that I can take pictures."

"That is what he has been working for," said his mother. "I am glad you have succeeded, Frank."

"You know, Don, when father gave me the land for the potatoes, and I got the blackberry plants? Well, I had just one thing in mind, and that was to earn money to buy a camera."

Now it was all explained. Frank had had a pur-

pose in the work that had brought him out so early in the morning and had kept him busy until late every evening.

"It will be worth your work, Frank," said Uncle Robert, laying his hand on Frank's shoulder.

"Will you buy the camera for me, Uncle Robert? I want the nicest one that can be had for the money. The rest of it is in the house. I'll get it."

He brought out the hard-earned money and gave it to Uncle Robert. "This is enough to buy a good photographic outfit," said Uncle Robert. "I have a friend in Chicago who will see to it for you. I will write to him to-night."

When Mr. and Mrs. Leonard talked over the proposed trip, Mr. Leonard said:

"Yes, the boys have worked hard all summer; they have been trustworthy, and I think it is a good plan to let them go. Their study of soil, drainage, and plants has given them more interest in the farm. I believe that the more they think the better they work."

At the breakfast table the next morning Uncle Robert said:

"Boys, how would you like to go on a long trip with me?"

"Where? When?" exclaimed both boys at once.

"To Wausau, in Wisconsin. We'll go there on the train and send the big boat up by freight. Then we'll put the boat on the river and come down."

"Row down!" shouted Donald.

"Yes, row down. We'll study the river all



along the way and camp at night wherever we happen to be."

"Can I take some pictures?" exclaimed Frank.

"Exactly what I want you to do," assented Uncle Robert.

"And I can go, too?" cried Susie, with shining, but anxious eyes.

"Not this time, Susie, dear," replied Uncle Robert, gently. "You're not quite big enough to take so hard a trip."

"Oh, oh, I want to go! I am big enough!"

Susie's head dropped on the table.

"I wish I were a boy!" she sobbed.

"It isn't because you are a girl that I don't take you, Susie. It is because you are not quite old enough to take care of yourself. We shall all have to row long distances."

Just then Susie felt Donald's arms around her.

"Don't cry, Susie," he said. "I'll write long letters to you and tell you all about it. Then, you know, if you should go, there wouldn't be any one to take care of Barri and Ebenezer. And who would feed my calf and the chickens for me? I don't believe I could go if I didn't have you to leave everything with."

Susie liked to help, and especially to help Donald. She looked up, drying her eyes.

"I'll take care of them, Donald," she said, "but I wish I could go with you."

"You shall go some other time," said Uncle Robert, cheerily.

Thenceforth there was nothing talked about but the trip. The camera came, and with it a small book telling how to use it. There was also another small package in the box.

"Here, Susie," said Uncle Robert. "This is for you."

Susie opened it.

"Oh!" she cried. "Paints! Thank you, Uncle Robert. Now I can make some pictures, too."

Uncle Robert and Frank worked out the directions for using the camera. Frank soon learned how to hold it, how to get the proper focus, and how to time it in the sunshine and shadow. It was a simple matter, though it required great care, and no end of fun to transfer the familiar scenes about the farm to the plates that were so sensitive to the least ray of light.

Donald helped him make a dark room in one corner of the cellar. Here, with Uncle Robert to explain the directions, he learned to develop his own plates and print his own pictures.

Everybody was busy now with preparations for the trip. The boat and baggage were packed and sent off by freight, and then came the time for Uncle Robert and the boys to say good-by.

Susie smiled bravely until they were out of sight.

Then she remembered her paint-box. "Come on, Barri," she said, "let's go down to the river. We'll have some pictures to show them when they come back."

At the junction the travelers met the express-train that was to carry them away up north. It was still early morning. From the car windows they saw white farmhouses and big red barns in the midst of groves of green trees. Between the stubble fields shorn of their yellow grain were broad stretches of corn with pennant-like leaves waving in the breeze and glistening in the sunshine.

The train plunged into cool dark woods of oak, maple, ash, hickory, basswood, and elm. Then the woods were left behind and they sped along through a region of low rounded hills. In some places, instead of going around the hills, the track was cut through them.

"What kind of soil is that hill made of?" asked Uncle Robert, as the train slackened speed through one of the cuts.

"It is just yellow clay," said Frank, "with stones mixed all through it."

"Did you see how the sides are all cut into little gullies?" asked Donald. "The rain did that."

In many of the hollows among the hills lakes were shining like silver in the sunlight. In others were marshes filled with coarse grass and reeds.

Then the appearance of the country changed. It became more level, and at the same time they saw a change in the trees. Pine-trees were mingled with the elms, the oaks, and the hickories. Then another change. Stumps everywhere.

"We are now in the lumber country," said Uncle Robert. "Once this whole region was covered with



pine-trees. We may see something of the logging and lumber trade while we are here."

"Here is a river," shouted Donald. "Is this the Wisconsin, uncle?"

Uncle Robert looked at his map.

"Yes," he said, "this is the Wisconsin River. We cross it here, but we are still a long way from Wausau."

The boys began to think they would never arrive, but at last the conductor shouted:

"Wausau!"

They gathered up their things gladly, and in a few moments more were on the platform looking for their boat.

## CHAPTER II

### THE FIRST NIGHT IN CAMP

A TEAM was engaged and the boat and packages were taken to the river, which was a short way off. The travelers launched their boat and stowed away their things all ready for the trip.

"Now we will go back and have supper at the hotel," said Uncle Robert.

"Can't we cook our supper?" asked Donald.

"It will take us some time to pitch our tent and make our beds."

So they went back through the streets of the little city. The air was pure and clear. The houses were neat and new. It was a pretty town, built on a plain close to the river, and nearly surrounded with low, rounded hills.

Supper over, they went in search of the boat, which was moored close to a steep bank. Here they had a fine view of the river.

"See the islands," said Donald. "I'd like to camp on one of them."

"We'll find a good place to camp," said Uncle Robert.

Each boy took an oar and helped to push the boat.

off into the current. Uncle Robert took charge of the rudder, and they started down the river.

Little rowing was necessary as the stream was strong and swift. It took all Uncle Robert's skill to steer them clear of the little islands and the bushes that grew along the shore. The sun was setting behind the hills as the current carried them by a beautiful island covered with trees which stretched their broad limbs out over the river.

"Where shall we camp first?"

"That would be a fine place to fish," said Donald, pointing to a little cove in the island.

"There will be plenty of good places to fish," said Uncle Robert. "Up near the dam I think we shall find more fish than there are here."

"I wonder what kinds of fish there are," said Frank.

"Bass are the best fish they catch, I think," said Uncle Robert. "There is a kind of fish that comes up in great numbers in the spring, and many people eat them, though the meat is very coarse. They are called suckers."

"I wish we could catch some bass to-night," said Donald.

"We could go quite a distance down the river this evening," said Uncle Robert, "but it looks very interesting here. It would be a good place to study."

"To study!" exclaimed Donald, in surprise. "We didn't come to study. We came for fun."

"I wonder if it would be possible to study and have fun at the same time," said Uncle Robert, smiling a little. "Shall we stop here?"

"Let's camp in the woods on this island," said Frank.

"It looks very nice in the woods," said Uncle Robert, "but I think we might find the mosquitoes pretty lively in there. That open place on the left bank of the river looks better. We should be apt to have a breeze there that would blow the mosquitoes away. Besides, I see a farmhouse close by where we can probably get milk and eggs."

"I am to do the cooking," said Donald. "You just wait and see me cook."

The current carried them to the bank. They tied their boat to the root of a tree in a little eddy. Uncle Robert went to the house and asked Mrs. Lilly, for that was the name of the owner, if they might camp upon the farm. Mrs. Lilly was very willing, and promised to let them have whatever they needed.

They rowed across to the island, cut some sticks with crotched limbs for the tent-poles, and also some tent-pins. They unrolled the tent, tied the ends of the ropes to the crotched sticks, spread out the canvas, hoisted it into position, drove in the pins, tightened them up, and the tent was ready. For their beds, they spread down rubber blankets first, then the warm woolen ones on top.

By the time all this was done it was quite dark. Donald was still anxious to try the fishing.

"Better leave the fishing until to-morrow, Donald," said Uncle Robert. "Let us sit out there on the bank, where the breeze will keep the mosquitoes off."

Looking up the river, they saw the lights of the city twinkling through the darkness. Overhead the stars were shining brightly. A fresh breeze came over the water.

"It's very pleasant out here," said Uncle Robert, after a while, "but it's time to go to bed, for we want to get up early in the morning."

"I'll get up at daylight and catch a fish for breakfast," said Donald, as they walked back to the tent.

A great stillness surrounded them as they lay down on their blanket beds. They were soon fast asleep.

In the morning Uncle Robert awoke to see Donald creeping quietly out of the tent.

"Going fishing," said he to himself, smiling.

Sure enough. In a short time Donald returned in triumph, carrying a big black bass. Frank went to the farmhouse for milk, while Donald cleaned and cooked the fish. Uncle Robert made the coffee, and breakfast was ready.

"How jolly!" exclaimed Donald, eating as he had never eaten in his life. "This is just what I like. Isn't it grand to have a tent and a boat on the river and live out of doors all the time!"

After a hearty breakfast the dishes were washed and put away and the little company was seated by the bank of the river. The current swept around close to their feet. The water gurgled and foamed, bringing bits of log, pieces of board, shingles, and laths. At their right they could see two islands covered with elm-trees. Up the river was a broad curve,

which reached down past their camp. The opposite shore was low and flat. Back of them was Mrs. Lilly's farm, which was nearly level. Back of the farm rose a high bank that began near the river above them and curved around until it reached the river again below.

"I love the country," said Uncle Robert. "The sweetest rest I have is when I am out in the country,



The camping-place.

away from the noisy, crowded city. Your mother has told you that when we were children we lived upon a New England farm. When I was a boy I knew a great deal about the farm and the land all around it. I can see it all now—the valleys and the hills and the plains, the fields and the kinds of land in each field. I knew about the plants and the birds and the animals. I knew just when and where to look for them; when the birds would come and when they would go away. I did not know it then, but I



studied a great deal when I was a little boy, and the best things I know now are the things I learned then.

"I thought then, and people generally thought, that the earth was made in a few days, and if there were any changes they happened all of a sudden. There were many boulders on the farm, but I never dreamed whence or how they came.

"Some years ago I bought some books upon geology and geography, and studied them. I found that learned men had changed their ideas about the creation of the earth, but the thing that interested me most was that the changes in the earth's surface are taking place all the time, just as they have been for ages. Then I looked back on the old farm and wondered that I had not thought of such things myself. I made up my mind that I would study the changes that are taking place upon the earth's surface, and when I came up to visit you I really began, and it has interested me very much.

"Then I thought of my boyhood and how much help it would have been to me if somebody had shown me how to study the Big Book. When I saw how interested you were in what little we have done upon your farm, I wondered if I could not help you more, though I know very little about it myself."

"I think you know a great deal," said Frank, enthusiastically.

"Not very much," replied Uncle Robert, "but I certainly want to learn something more of how God is creating the world."

"I think it will be fine to study with you," said

Frank. "I enjoyed the study on our farm very much."

"Was that study?" asked Donald. "Well, that was the best fun I ever had."

"I am glad you think so," said Uncle Robert. "And now we will try to learn something more. Perhaps our study on the farm will help us here."

"How shall we begin?" asked Frank.

"Well, I will tell you. When you went to school did your teacher ever give you problems in arithmetic to work out in the evening?"

"Oh, yes," said Donald, looking sober.

"I used to have them, too, and I liked to solve them very much. But there are some problems around us here quite as useful and more interesting, I think, than those in the arithmetics."

"Problems!" said Donald. "I don't see any problems."

"There are many of them, even if you do not see them, and I want you to help me work them out. All these objects around us ask us questions. This bank that the current is taking away, and this farm and that great curved bank back there, and these islands—all ask us questions, if we can only hear or see them. They are certainly right before us. They have been before man's eyes all through the ages, but it is only within a few years that learned men have tried to answer the questions that these objects are always asking. All this land which we see has a history—that is, a story of its growth. This river-bank, this plain, and that ridge up there, all have



histories. They were made in some way, and they are changing all the time, just as that bank right there is changing."

"The water is wearing that away," said Frank.

"Yes, that is one way by which the earth is changed. Now let us look for some problems. We will take them one at a time. What do you think would be a good one to begin with, Frank?"

"I'm sure I don't know," answered Frank. "We can see that the water is wearing away this bank. That is an easy one."

"Yes, and I see another one," said Uncle Robert. "What made that steep curved ridge back of Mrs. Lilly's?"

"That must have been there always," said Donald.

"Always is a long time, Donald," smiled Uncle Robert. "None of this land has been here always. It was made in some way, and I believe we can find how it was made."

"I'd like to know how to begin," said Frank.

"One thing we should do with great care, and that is, study the material of which the land is made."

"Why, the land is made of dirt," said Donald.

"Some land is solid rock," said Frank.

"What do you call this land here by the bank?"

"This land is soil or loam," said Frank.

"Then you know that there are different kinds of earth?"

"Yes, there are gravel and sand and clay."

"It is of great importance, then, that we know the minerals of which the land is composed, for they all

tell something of how it is made. Then we study the forms of the land—that is, the forms of the surface. This land right here is——”

“Level,” said Donald.

“Not quite level,” said Frank; “it slopes a little, and is uneven.”

“What would you say of the land back of the farm?”

“That is much higher.”

“And that land over there?” pointing across the river.

“That is a hill.”

“It looks like a mountain,” said Donald.

“Now, there are two things that we must study very carefully; first, of what the land is made, and second, the forms of the land—how the land slopes, or whether it slopes at all. Knowing these two things, we may be able to solve some of these problems. What is the problem nearest us?”

“It might be, how this bank was made. And now I can guess what you mean by land changing all the time, for the current is taking this land away and carrying it down-stream.”

“Our river at home is taking away a great deal of Mr. Davis’s land,” said Donald.

“If this river runs against the bank here a great, great many years, it will take away the whole of this farm, won’t it?” asked Frank.

“What do you think?”

“It must take it away in time if the current keeps on digging into this bank.”

"It is digging right under the bank now," said Donald, who had slipped down close to the water.

"If the river wears away all of Mrs. Lilly's farm, then it will run right up close to the steep place," said Frank.

"That seems to be true. Here is our first problem, then, in the work of water. We shall find a great many."

## CHAPTER III

### FRANK FINDS A HARD PROBLEM

THE tent on Mrs. Lilly's farm was close to the left bank of the river. From there the long, uneven plain ran back to the high, curved bank. Frank sketched it with his pencil. He was eager to take his first picture, so they started off on their field excursion.

"Do you suppose we can tell how that high, curved ridge was made?" asked Frank.

"That certainly is a good problem," said Uncle Robert. "Do you think the river ever flowed near it?"

"I do not see how it could," said Frank. "It's too far away and all this land is in between."

"Here's a gully in the bank," shouted Donald. "It looks like the one in the path to our spring, only it is a great deal deeper."

At the head of the gully trees and bushes were growing. At its foot were piles of small stones, gravel, and sand.

"I can tell what brought all that stuff down here," said Donald. "Water did it."

"There's no water in the gully now."

"But there is every spring, and there is water in the gully whenever it rains here."

"Or when the snow melts," suggested Uncle Robert.

"Then the water in the gully brought all this sand and gravel down here and spread it out."

"Do you notice how it is spread out?" asked Uncle Robert.

"It looks just like an open fan," said Frank.

"Yes, that is the name they give it. When the water brings down earth and spreads it out that way, it makes what is called a fan."

Frank took a picture of the gully. While he was adjusting his camera, Donald busied himself collecting the pebbles. There were many different kinds and colors, and he soon had his pockets full. Close to the mouth of the gully were some large boulders.

"What is the problem here?" asked Uncle Robert.

"Why," said Frank, "how the gully was made."

"That is an easy problem," said Donald. "The gully down the path to our spring was made by running water, and running water brought down these pebbles and this sand, and it must have made this gully."

"But did it bring down the boulders?"

"There are lots of boulders in the bank. You can see them all along," said Donald.

"Now tell us the whole story of the making of the gully."

"Well, a long time ago, the bank here was just like the bank out there, where there are no gullies. Then in the spring when the snow melted, a little stream of water began at the top of the bank. It ran down and washed away a little of the earth. Every time it rained, it cut into the bank a little more, and washed down the sand and stones. Every spring and every time it rained the gully grew deeper and deeper."

"Do you think the rains wash it much now?" asked Uncle Robert.

"There must be just as much rain now as there was when the gully began," said Donald.

"But see all those bushes and trees up there," said Frank. "Their roots hold the soil and keep it from washing away."

"You are both right," said Uncle Robert. "We can never know how much deeper this gully might have been but for those trees and bushes. We can tell now what this ridge is made of, and the land back of it. The gully tells that."

"It must be made of gravel and boulders and sand," said Frank, "if it is all like the gully."

"But how did they come here?"

"Oh, Uncle Robert," said Frank, "how could they have come here unless they were made here?"

"That is a good question, but perhaps we can answer it better when we have seen more. Let us go up to the top of the ridge."

So they climbed up the slope and soon reached the top. They found quite a level country above. There were farmhouses scattered here and there, but the



soil did not seem very good for farming. They walked slowly along the edge of the slope. Below them on the right was the plain that reached to the river. On the left stretched out the level land, and in the distance was a long rounded hill.

"If the river were flowing up close to this steep slope," said Frank, "I should say the river made it. It is more like a river-bank than anything else I know of."

"But the river is away over there," said Donald, "and rain couldn't make this slope as it made the gully, not even in the spring floods."

"No," said Frank. "I can't see how rain could make this curve. Just look at it! It starts from the river up there, curves away around here, and down yonder it is close to the river again."

"I think," said Uncle Robert, smiling on their serious faces, "that is a good problem, don't you? Perhaps I know how it was made, but I am sure you would rather solve it for yourselves than to have me tell you, wouldn't you?"

"Oh, yes," said Frank. "I want to see if I can make it out for myself."

They walked along the edge of the steep bank until they came to the river. Then they turned back toward the camp, now watching the rushing water, and now looking across the plain at the steep, high bank which was their main problem. Frank pointed across the plain and said:

"See, there is another bank between the river and the high steep bank."

Sure enough, a bank a few feet high lay between them and the ridge over which they had just walked.

"These problems are rather too much for me," said Frank. "I can't understand how that bank was made."

"Suppose," said Uncle Robert, "we take one thing at a time. Let us look at the bank of the river close to us."

"See these trees," said Donald. "The river will take them away by and by."

The roots on one side of the trees to which Donald pointed had been washed bare.

"When there comes a big flood," said Donald, "it will take these trees down the river."

They stood on a point where they could see the bank of the river, the high bank in the distance, and the low bank between.

"Didn't running water make all three of these banks?" asked Frank, looking from one bank to the other.

"The idea!" laughed Donald. "How could that river away down there make those banks so far away from it?"

"Perhaps," said Frank, "at one time the river flowed up there. You know there is a curve in the bank of our river on Mr. Davis's farm. And there's the curve in this bank. Right close to our house there is a slope, and it curves away from the river as this one does. It is not nearly so steep as this one is. Didn't you say the river made our slope, Uncle Robert?"



"Yes, I think I did."

"Well, the current is flowing on Mr. Davis's side of our river now, and it is cutting into his bank. There is only one way a river can make a bank, and that is by the cutting of the current into the land. So if the river made our slope, then sometime the current must have flowed on that side. Isn't that true, Uncle Robert?"

"Yes, that is right."

Frank's face glowed with delight. He was working out the problem.

"Do you mean," asked Donald, "that the river flowed away round there once?" pointing to the high bank.

"Can you think of anything else, Donald, that could have made that steep, curved slope, if the river did not do it?"

"No; but how did the river ever get away over there? There must have been a great deal more water in it than there is now."

"That's another fine problem for us to work on," said Uncle Robert. "But let us see if we can find any other means by which the bank could have been cut."

"I can't," said Frank. "It wasn't made like a railroad cut, that is sure. Rain alone couldn't have done it; so I think it must have been made by the river."

"Let's just say that the river did it," said Donald, "even if we can't tell what happened to change it so much."

"It isn't safe to jump at conclusions, Donald. It is best to get all the proof we can before we decide any question. Perhaps after we have seen more and examined the soil more closely, we can tell better. Let us make some drawings now, and show, if we can, just how the land slopes."

So they went back to the camp to rest under a wide-spreading elm-tree. Birds were flying everywhere, and as Donald lay on his back in the leafy shade he called all he knew by name. Frank and Uncle Robert were busy with the drawings. When they were made, Frank looked at the shadows of the trees, then at the sun.

"I think it is noon," he said. "Let's have lunch."

"All right," said Donald. "I'll get it."

He ran to the tent. Soon the sputtering of the ham and eggs in the frying-pan drove all thoughts of rivers, slopes, and plains from his mind.

## CHAPTER IV

### AN AFTERNOON WALK

WHEN lunch was over, Uncle Robert said:

"We will take a long walk this afternoon. Bring the camera, and we'll see what we can discover."

"How swiftly the river flows!" said Frank, as they walked along by the deep, broad stream. "It is ever so much swifter than the river by our farm."

"What makes a river flow, anyway?" asked Uncle Robert.

"The slope of the land," said Frank.

"What do you call the land over which the river flows?"

Frank looked at the river.

"Why, that is its bed."

"Sometimes when there is a flood it has a pretty wide bed," said Donald.

"That is true," said Uncle Robert. "And when there is a drought the bed is often very narrow. We will call the bed of the river and the banks on either side the river channel."

They came to a bridge over a deep gully. In the middle they stopped and looked down. The sides of the gully were very steep. It was like a deep

ravine or gulch. At its bottom a creek flowed rapidly on its way into the broad river.

"Did water make this great deep gully?" asked Donald.

"What do you think?"

"I think it did," said Frank. "We know it made the little one in our path, because we saw it. We know it made the one we passed this morning, because we could see where it had washed the soil down. Now this is just the same, only it is much deeper; so the water must have made it, too."

"It must have taken the water a long time to make this gully," said Donald, looking over the side of the bridge to the creek below. "That is a queer place to make brush heaps," he added, pointing to one side of the gully, where were great piles of dead trees and bushes.

"I think they are there for a purpose," said Uncle Robert.

"And I believe that purpose is to keep the land from washing away," said Frank.

"That is right," said Uncle Robert. "The sides of the gully are steep and this sandy soil is easily washed away by the rains. Then, too, when the frost comes out of the ground in the spring, the soil is loosened up and it is very easily washed down into the creek."

"And the creek carries it into the river," said Donald. "I wonder what the river does with it?"

"Perhaps we shall soon see."

"In spite of the trees and bushes, the gully is being made wider," said Frank.

"Yes, all the time, but not so fast as it would if they were not there. What stopped the gully of which you took the picture this morning from becoming wider?"

"The trees and bushes growing in it."

"What do they do?"

"The roots hold the soil. I think live trees are better than dead ones," said Donald.

"But in the gully we saw this morning there was no creek. In this one there is quite a stream. What makes the difference?"

"That is another problem and a very good one, but let us go on and not try to solve it now."

They walked on to Wausau and strolled through the streets.

"This is not a very old city," said Uncle Robert. "One way by which we can tell is by the size of the trees. In New England the trees in the cities are very large and beautiful; for there, you know, are some of the oldest cities in the United States. New Haven is called 'the City of Elms,' because of the great beauty and size of its elm-trees."

"The land around here isn't very good," said Frank. "There is too much gravel and sand. It can't be a good farming country. I don't see why a city was made here at all."

"You will solve that problem very soon," said Uncle Robert. "Let us go to the top of one of these hills, where we can take a good look about us."

There were hills all around the city. They climbed one on the east side, where Frank took a



Wausau and "The Rib."



picture. Below them lay the little city with its small, neat-looking houses. Beyond the city curved the river, over which rose a slight mist.

"This is a fine view," said Uncle Robert.

"Isn't that a mountain?" asked Donald, eagerly, pointing to a long, low, ridge-like hill.

"In some places people would call that a mountain, but here it is called a hill. The name of that hill is 'the Rib.' Now I will tell you something, boys. That hill which we can see yonder was once a mountain, probably thousands of feet higher than it is now."

"Thousands of feet higher!" exclaimed Frank. "How do you know that, Uncle Robert?"

"It looks as if it had always been just as it is now," said Donald.

"Yes, it does look so; but even now it is changing, although we are not able to see it."

"Well," said Frank, "it puzzles me to see how anybody ever worked out that problem. I am sure I never could."

"A great many wise people have worked a long time over these problems," said Uncle Robert. "We will try to solve them, but we will get some help from those who know more than we do. We can not do it all by ourselves."

"That hill over there is just like this one," said Donald; "only it is bigger."

"What is that hill you called 'the Rib' made of?" asked Donald.

"It is made of what is thought to be the oldest

rock in the world, though that is still an open question."

Frank took the glass and looked at the hill.

"I can see rough places at the top," he said. "It isn't so smooth as these smaller hills are."

"Before we go down the river we will pay a visit to that long hill. But now, take a good look over the city and see if you can discover why it was built here."

The boys took turns at looking through the glass.

"What are those big buildings away over there by the river?" asked Frank.

"They are sawmills, lumber-mills," said Uncle Robert.

"And there is a dam," said Donald. "It is a larger dam than ours. I can see great piles of lumber."

"You remember the stumps we saw as we came on the cars?" asked Uncle Robert.

"Oh, is that where all the lumber came from?" cried Donald.

"Some of it, perhaps. Not many years ago this whole country was covered with a thick growth of timber, mostly pine. It was a valuable kind of pine, called cork pine. The lumbermen came into the deep woods, made their camps, and cut down the trees. They floated the logs down the river, sometimes loose and sometimes made into rafts. The logs are cut in the winter and floated down in the spring. Can you think of any reason why the spring is the best time for such work?"



"Oh, I know," said Donald. "There is more water in the river in the spring."

"And it flows with such force that it can carry an immense load. I wish you could see a log jam. But we may meet some men who work upon the river who can tell us stories of the life in the woods. When



Floating logs.

the timber was cut, mills were needed to turn the logs into lumber. So men came here and built them.

"And when they built the mills they built houses to live in," said Frank.

"And that made the city," said Donald.

"Yes, now we know why the city is here."

"It is a lumber city," said Frank.

"I should like to see those sawmills," said Donald.

"We will go over and take a look at them," said Uncle Robert.

As they walked toward the sawmills Frank asked:

"What will they do when they have cut off all the trees?"

"I don't know," said Uncle Robert. "That is a problem which I can not solve."

It was evening when they returned to the tent. Donald made a fire, while Frank went to Mrs. Lilly's for milk and eggs. They watched the sun set and the long twilight come on, but they were very tired, and soon went to bed.

The next morning when breakfast was over they sat on some logs that had been brought down and dropped beside the river.

"Well, what is our first problem?" asked Uncle Robert.

"Why, the first thing is to decide how these banks were made."

"We know about this one," said Donald. "The river is making it now. I have been watching it, and I am sure of it. See these pebbles," taking them from his pocket. "I found them down there, close to the water. There are lots of them, all just as round and smooth as these are. I dug under the bank close to the water and found them as far back as I could dig."

"We are sure of one thing," said Uncle Robert; "the river is making this bank."

"Mrs. Lilly told me this morning that she had lived here for forty years," said Frank. "I asked her if the water wore away the bank, and she said that it has worn away more than twenty feet since she has lived here. You see that tree with its roots hanging over the bank? She said the road to the pasture was once on the other side of that tree, just where the current is now."

"Did you ask her if the river ever flowed up by that high ridge?" asked Donald.

Uncle Robert laughed.

"If the river made that bank, it did it many, many years before there were any people here to see it. It may have been many thousands of years ago."

"If it was made so long ago," said Frank, "how in the world can we ever tell how it was done?"

"Well, we can try," replied Uncle Robert.

"Then this little bank between that high, steep bank and the river; how was it made?"

"I am sure the river did it," said Frank.

"And if so, where did the river flow?"

"It must have flowed close to the bank it was making."

"I think that is true. Now the first part of our problem is solved. The river is making this bank now, and it made that little one back there years ago. If it also made the high one beyond, where did it flow then?"

"Around that curve. But was the river at first on a level with the top of the high bank, and did it cut clear down to the plain?"

"What do you think?"

"It must have done so. That is the way our river-bank was cut."

"Then was this land where Mrs. Lilly's farm is now once the bed of the river, with that high bank for one side of the channel?" asked Donald, looking puzzled.

"It seems so," said Uncle Robert.

"Then how was it all made, I'd like to know?" said Frank.

"That is our next problem, and it is a good one. We must begin to work it out, but we can not do it sitting here. I want you to draw a profile of the farm from the high bank to the river. Then we will go in different directions and see what each one can discover for himself."

## CHAPTER V

### HOW A RIVER WORKS

THEY met under the big elm-tree.

"Well, Frank, what did you find? Have you solved any problems?"

"Not yet, Uncle Robert; but I'm beginning to work out some of them."

Frank took his pencil and drew the curve of the high bank. (Fig. 1.)

"Make the slope as you did when you drew the

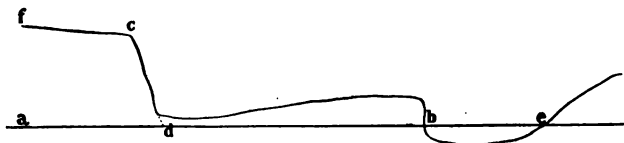


Fig. 1.

map of the farm," said Donald, who was looking on.

When the slope was drawn Frank said:

"This is the way the river flowed once, and the current was close to this bank *c-d*. The river must have cut down and down for nearly twenty-five feet. I think this bank is about twenty-five feet high."

"It must have taken a very long time and very deep water to do all that," said Donald.



"It is always the deepest where the current is," said Frank.

"If it was deepest close to this bank it was shallow on the other side of the river," said Uncle Robert. "Draw the bed of the river, Frank, as it must have been when the current flowed close to this bank." (See Fig. 1.)

"This line, *a-e*, is the level of the water," said Frank; *d* is the bed of the river when it flowed close to the bank, and *d-c* is the bank. I think it must have been steeper then than it is now."

"Why?"

"That is the way it is in our river. The bank on Mr. Davis's side, where the current is cutting now, is very steep. On our side, which is the old bank, it is more sloping."

"Can you think of any reason for that?"

"I can," said Donald. "When it rains the water runs down our slope and carries the soil to the foot of the hill, and there it stops. So, while the hill is being cut back at the top, it is being built out at the bottom, and that makes it slope. On the other side the water cuts under the bank and carries the soil away as fast as it is worn loose. That keeps the bank steep."

"That is a very good explanation, Donald," said Uncle Robert.

"Well, I've seen that ever so many times," said Donald. "I couldn't help it."

"Can you draw a profile of this land as it is now?"

Frank went to work again with pencil and paper and drew the lines as in Fig. 2.

"The line *a-e* is the level of the water," he said; "*c-d* is the bank cut by the current."

Donald was watching very closely.

"That's right," he said. "Make it slope more than it did when the river was cutting it."

"I am making it as it is now," said Frank, look-

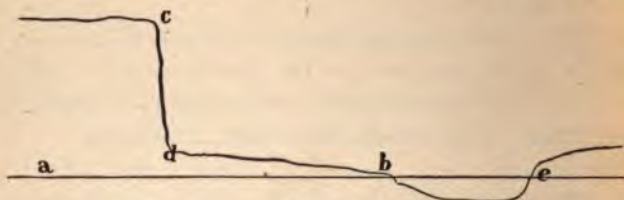


Fig. 2.

ing across the plain toward the high bank. "*d-b* is the land between the bank and the river."

"How did it get there?" asked Donald.

"That is our present problem," said Uncle Robert.

"I call it a first-class one, too."

"Well," said Donald, "if the current cut the bank that far down, I don't see why it stopped."

"It must have left that side of the river," said Frank.

"What made it change?" asked Donald.

"That is what puzzles me," said Frank.

"Where did it go?" asked Uncle Robert.

"I think it went to the other side of the river," said Frank. "I followed this steep bank clear down till it came to the river again. There I saw that the current must have crossed the river and flowed on the other side, for the bank is cut very much as this one is."

"How did it cross the river?"

"Like this. When it came to the lower end of the curve at *a-b*, it went straight on, and that carried it to the other side of the river."

"Diagonally," suggested Uncle Robert.

"What do you mean by that?" asked Donald.

"Why not straight across the river, but slanting, so that when it reached the opposite side it struck the bank a little lower down the river," said Frank.

"Then it would cut into that bank," said Donald; "and that would make a curve there, with a steep bank."

"What brought the current across to the bank at *a*?" asked Uncle Robert. (See Fig. 3.)

"There must have been another curve on the other side farther up the river," said Frank, after a moment's thought. "It seems to me that the current of a river flows zigzag—so."

He took his pencil and drew a zigzag line across the paper.

"It strikes the bank at *a*, and that sends it over to *b*. Then it is turned back to *c*, and so on."

"But there are no sharp corners in the flow of a current," said Uncle Robert.

"Of course not," said Frank; "for where the current strikes it cuts away the bank, and that makes a curve. This is the way."

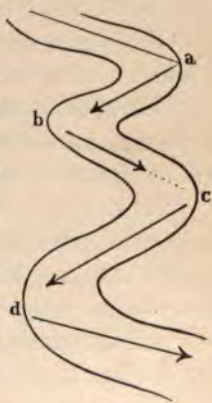


Fig. 3.



He drew a curved line on either side to show the course of the river. (See Fig. 3.)

"But rivers don't flow in such regular curves as those, do they?" asked Donald, looking from the drawing to the river.

"Not often," said Uncle Robert; "for there are many things that affect the flow of a river. Then, as the bank is cut away more and more, the direction of the current changes until after a long, long time the course of the river is completely changed, too."

"I believe that is just what happened here," said Frank.

"And if the current did swing from this bank over to the other side, what did it leave here?"

"Shallow water," said Frank. "The deep water would be on the side with the current."

"Look at the figure you have drawn of the bed of the river and the level of the water when the current was close to the bank." (See Fig. 1.)

"At first it would be deep close to the bank, because the current was there."

"What has happened since the current swung over to the other side?"

"All this land between *d* and *b* came here," pointing to Fig. 2.

"Now we have our problem," said Uncle Robert.

"And that is how Mrs. Lilly's farm was made," said Donald.

"It seems to me," said Frank, thoughtfully, "that it is something like our big cornfield. You said that was made by the river."

"But that is a flood plain," said Donald, "and this isn't. Mrs. Lilly says the water never covers this land in the spring. It reached almost up to the top of the river-bank here years ago, but it went no higher."

"Well, anyhow," said Frank, "I don't see how it could have been made any other way. You remember when we have a flood how muddy the water is. Then after the flood goes away the cornfield is covered with the dirt the river has left. Of course it isn't much, but every year adds a little."

"Yes," said Uncle Robert, "most rivers carry a great deal of soil. But very little is deposited under the current."

"That is because the current is so swift," said Donald.

"Well," said Frank, "if the current left the steep bank and went to the other side the water would be slow here."

"And what would happen?"

"Then the soil in the water would be dropped here. That is the way it is in our river. When the cornfield is flooded the water flows so slowly we can hardly see it move, and that is where the earth is dropped. It is never left on Mr. Davis's side. He wishes it were."

"So, if the water flowed very slowly on this side of the river, what happened?"

"The soil brought down by the river was dropped here," said Donald.

"And that filled up the old channel until—why,

until the old bed of the river came up to the surface of the water," cried Frank.

"Then what?"

"Why, then it wouldn't be the bed of the river any more," said Frank.

"Yes, it would when there was a flood," said Donald, thinking of the cornfield at home. "Then the river would rise and flow clear over to the bank again."

"Donald is right," said Uncle Robert. "And what would happen in the floods?"

"Every time there was a flood the land would be built up higher, because in a flood the river brings down more earth than at any other time."

"How would it look when the flood was gone?"

"Oh, it would be all mud and sand."

"And gravel," interrupted Donald. "Uncle Robert, I believe those pebbles I found down by the river were left there when the land was low. You know I dug under the bank and found them as far back as I could dig. Do you believe there is a layer of pebbles under this farm all the way back to the high bank?"

"I think it very likely. How do you think the land sloped then, Frank?"

"I think it was this way," said Frank, drawing a profile. (Fig. 4.) "The floods came year after year for a very long time."

"Thousands of years," suggested Uncle Robert.

"Yes, perhaps so; I don't know how long. But after a while it had built up the old river channel until it became a beach."



"Which way did it slope?"

"Toward the river. This line, *d-b*, is the beach."

"Then what was the current of the river doing?"

"Cutting the bed deeper on the other side all the time."

"It was cutting into the bank, too," said Donald.

"*b-e* is the new channel of the river," said Frank, pointing to his drawing.

"If the current is cutting away the bank and

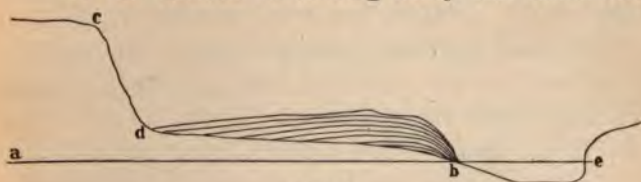


Fig 4.

making its bed lower at the same time, what is happening to the surface of the water?"

The boys looked closely at the drawing.

"Oh, I see!" cried Frank at last. "The more it cut on the other side, the lower the river would be and the higher it would leave the land on this side, the beach from *d* to *b*."

"That is right. Now can you tell me all about it?"

"Well," said Frank, "first the river flows along that bank and cuts it down. Then the current swings over to the other side of the river and begins to cut there. The water moves slowly now on this side, where the current was before, so the earth brought down by the river is dropped here, and little by little it is filled up on this side."

"That is right," said Uncle Robert. "Then what?"

"After a while it is filled up so high that a beach is formed," said Frank.

"And when the river is low in the summer the beach is above the water. But when the floods come in the spring it is covered clear back to the old bank, and more earth is spread out all over it. This is done year after year, making the land higher and higher."

"And all the time," added Donald, "the current is at work on the other side, cutting into the bank and making the channel deeper."

"What then?" asked Uncle Robert.

"By and by the beach is away up above the reach of the floods," said Frank.

"Will that be the way with our cornfield?" asked Donald.

"Yes," answered Uncle Robert, "if the current continues to flow next to Mr. Davis's farm a great while longer."

"But there is one thing I don't understand," said Frank. "The land here slopes toward the old bank. Why is that? I should think it would slope toward the river."

"The beaches slope toward the river, do they not?"

"Yes, I am sure they do."

"Then if this is a beach, why doesn't the land here slope toward the river?"

"One thing I can see is that the land next to the

bank was lower to begin with, because the current flowed there."

"That may have something to do with it," said Uncle Robert; "but you have seen your river rise, have you not?"

"Oh, yes," said Donald, "many a time. Before the flood the river is so clear we can see the bottom of it. Then the water changes and looks like thick coffee."

"That is because it is so full of earth," said Frank.

"But when the river rises and spreads out what happens?" asked Uncle Robert.

"Why, the current is swifter and stronger than at ordinary times, so it carries more soil. But when it spreads out it flows more slowly, so it drops the earth."

"And where will it drop the most?"

"It will drop the most where it is the slowest, and I think that is at the place where it begins to overflow," said Frank.

"Yes," said Uncle Robert. "The water rushes along loaded with soil, sand, and pebbles. The moment it flows over the edge of the beach it slows up, and so drops the greater part of its load there. Can you draw a profile showing how the land would be formed in this way?"

Frank took his pencil and drew the profile of the beach as he had drawn it before. (See Fig. 2.)

"Well," he said, "the first flood would drop the earth here," drawing a short line over *b*. "Then the next would make it a little higher and the next higher still." (Fig. 4.)

As he talked he drew line after line, one over the other.

As Donald looked on he cried:

"There! now it is higher close to the river than it is by the bank. That is just the way it is on this farm. And the river made it all."

"This afternoon let's walk back to the high bank again," said Frank. "I want to see it once more."

"Very well," said Uncle Robert. "We will rest now before we work any more problems, but when we do go I want you to notice the soil. Perhaps we may soon be able to tell why Mrs. Lilly's farm is so much better than those we saw back on the higher land."



## CHAPTER VI

### A NEW KIND OF GRIST-MILL

As they strolled along that afternoon the boys looked over the plain with new interest.

"Just to think of the river having brought all this soil here!" said Frank. "I understand now what you meant, Uncle Robert, when you said the river is a great worker."

"Yes, it is always at work," said Uncle Robert. "How far do you think it carried this soil?"

"Why, from the banks above here where they are being cut away," said Donald; "especially where they curve."

"That would account for a great deal of the soil here," said Uncle Robert; "but not for all of it."

"Well, there are streams flowing into this river," said Donald, "like our creek at home and the creek we saw yesterday. They bring some of it."

"Yes, the tributaries," said Frank. "They all have banks, and they must be cutting them away all the time."

"You are right," said Uncle Robert, "but there is still another means by which this land came here. When it rains on the fields at home, what do you see?"



"If it rains very hard the water runs off the surface and it always takes a little soil with it."

"That is the way the gully in our path was made," said Donald.

"And you know how muddy our creek is after a rain," said Frank. "The water runs off our fields into the creek, so the earth in it must come from the field too."

"It is just so here," said Uncle Robert. "All the land above here through which this river and its tributaries flow, and all the land that is drained by them, gives up a little of its soil. All taken together have made this land here."

"They must have been all mixed up before they got here," said Frank.

"Yes. This river and its tributaries flow through many different kinds of soil. These soils are made up of all kinds of mineral matter. The river has taken them up, mixed them together, and dropped them here. So if we could sort this soil over and know all the kinds of minerals which make up the thousands of acres drained by this river, we would find some of every kind of mineral right here. Much of the cultivated land on this earth is made in this way."

"Made by rivers?" asked Donald.

"Yes, made by rivers. You can see now what great use rivers are. Some one has said that a fifth of all the people of the earth live on land made by rivers."

"Not many people could live on Mrs. Lilly's farm."

"No; but in some places the land made by rivers is many miles wide; thirty, forty, fifty, and often sixty miles wide. You have read about Egypt, the land of the Nile, which is all made by the river. This valley is only about seven miles wide, but the soil on top of the sand is from thirty to forty feet deep. Many thousands of acres have been made by the Mississippi below Cairo."

As they walked back toward the river Uncle Robert said:

"Now you know how the land on this farm was made. By and by we shall see other flood plains and talk about some of the great flood plains scattered all over the earth."

"But this isn't a flood plain now," said Donald. "It was when the floods covered it, but when it became so high that the floods couldn't cover it, it wasn't a flood plain any more."

"That is right," said Uncle Robert, sitting down on the bank of the river under a wide-spreading tree.

Frank went to the tent for his camera.

"I'm going to take a picture of that island out there," he said.

When the picture was taken he asked.

"Uncle Robert, how was that island made?"

"The current flows on the left bank," suggested Uncle Robert.

"Which do you call the left bank?" asked Donald.

"The left-hand side as you go down the river."

"Then we are on the left bank, and across the river is the right bank."

"When the current was on the right side of the river that couldn't have been an island."

"Why not?"

"Because the water was so shallow on this side."

"It is deep now," said Donald.

"Which way does the land of the island slope?"



The island.

Frank looked carefully and then began to draw. (Fig. 5.)

"It slopes toward the channel next to the land on this side," he said.

"I will tell you about it," said Uncle Robert. "This land where we are was once a flood plain. Gradually it became higher and the river-bed on the other side became lower. Now what part of this flood plain would rise above the water first?"

"The highest part," said Frank, "and that would be next to the river."

"And where would the high floods go?"

"They would still go around by the steep bank, here at *a*," said Frank, pointing to the drawing.

"Well, suppose there was a great flood and the water flowed very swiftly around by the steep bank at *a*?"

"It would cut it out," said Frank.

"And if it cut it down so the water flowed by the steep bank all the time, what would the higher land become?"

"Why, it would be an island," said Donald. "Is that the way this island was made?"

"What do you think?"



Fig. 5.

"I think it must have been so."

Donald looked at Frank's drawing.

"There was a flood plain from *a* to *d*, and the lower part of it was next to the bank at *a*. Then there came a great flood and cut a channel from *a* to *c*, and that made the higher part of the flood plain from *c* to *d* an island."

"That is the way a great many islands in rivers are made," said Uncle Robert.

They walked along the bank and examined the roots of the trees that the water had laid bare.

"What will happen if this current flows for a long, long time on this side?"



"It will cut Mrs. Lilly's farm all away," said Frank.

"Then that steep bank back there will be the bank of the river again," said Donald.

"But there is the other bank not so high as the steep one," said Uncle Robert. "How high do you think it is?"

"About four or five feet."

"What made that bank?"

"We know the river must have made it," said Frank.

"How?"

"I suppose after the old flood plain was made the current swung over here and cut it away."

"Then what did it do?"

"It went back to the other side again, and built a lower plain down here."

"I can draw it," said Donald.

He took the pencil and paper and made a profile of the three banks.

"There it is," he said, proudly. "I don't need to tell you about it. You can see it for yourselves."

"It is very good," said Uncle Robert. "So you see that the current of the river swings from side to side and never stops. Where the current is cutting the banks away they curve in—that is, the banks are concave. Where the flood plains are being built the banks curve out, or are convex."

"The high banks are opposite the flood plain," said Frank, "so the concave bank is opposite the convex. Is that right?"

"It is generally so if the two banks are of the same kind of material," answered Uncle Robert. "As I told you this morning, there are many things that affect the curves of rivers, and in some places the curves are so gradual that they are hardly perceptible."

"I wish I could see the bed of the river," said Frank. "I have been trying to see down through the water. In some places I can see stones and boulders, but in others there seems to be only fine sand."

"You know that is the way we found it when we went in swimming," said Donald.

"Yes," said Uncle Robert, "the bed of the river is covered with sand, pebbles, and boulders. The sand is constantly washing down and the boulders and pebbles are rolling over and over. They are all moving continually."

"Is it the water that makes the stones so round and smooth?" asked Frank.

"No," replied Uncle Robert. "The water moves them all, but it does not make them any smoother."

"What does make them so smooth?" asked Donald, taking some pebbles from his pocket to look at them.

"As they all move along in the water they must rub against each other," said Frank.

"Yes, and that is called friction. The water is simply the force which moves them, just as you are the force that moves the saw when you saw wood; but it is the saw which does the cutting. A stone or

boulder is dug out of the bank by the river and falls into the stream. Then as it rubs against other stones it either grinds off their surface or is itself ground off.

"What becomes of what is ground off the stones?" asked Frank.

"Some of it is sand and some is mud. Some of it makes the fine soil in this farm."

"Then the farther a boulder travels in the river the smaller it becomes," said Frank.

"Yes, boulders become small stones, small stones become pebbles, and pebbles become fine sand."

"I should never dream that the river could do so much work," said Frank.

"It is never idle," said Uncle Robert; "but you know when it does the most work."

"Usually in the spring," said Donald.

"Yes; then the water rushes along with tremendous force. It tears away banks, digs up trees, and rolls big boulders over and over each other. The greater the flood the heavier the load it can carry. But when the floods go down, the water flows more slowly, and then it must drop a part of its load. The heavier burdens are dropped first, but the light, fine soil is carried great distances. All the time the stones and boulders are being ground smaller so that each time the river takes them up it carries them a great distance."

"What a great mill the river is!" said Frank. "I can understand now why you called it a mill the day we had our picnic on the island."

"What do you think is under all the material that



moves?" asked Uncle Robert. "There must be something under the moving sand and stones that holds firm."

"I think it must be solid rock," said Frank.

"Yes, it is very often solid rock."

"Then I don't see how the bed of the river can be made any lower," said Donald.

"Why, if the boulders and gravel and sand are grinding each other," said Frank, "I can see how they would grind the solid rock too."

"Yes," said Uncle Robert, "it takes a long time, but that is what is done."

"And all the earth dug out by the tributaries and all the soil washed off the land is carried down by the river," said Frank, his eyes wide open with wonder.

"Yes; and there is a great deal in the river that we can not see," said Uncle Robert.

"What, in the water?"

"Yes. If I put some sugar in a tumbler of water what becomes of the sugar?"

"It is dissolved," answered Donald.

"Can you see the sugar after it is dissolved?"

"No, the water is the same color it was before."

"And if I put salt or alum in the water?"

"They dissolve, too."

"But are they still there?"

"Oh, yes; but you can't see them."

"Yes, they are there, but in solution. Now there are a great many things in the earth that dissolve just as sugar, salt, and alum do. The rain-water finds

these particles, and is still all the time dissolving them. Then the water runs into the rivers, and the rivers carry them away in solution."

"But this stuff in solution doesn't stop anywhere, does it?"

"Not much of it," said Uncle Robert. "You know the ocean is different from this river."

"The water in the ocean is salt."

"But the water from the river flows into the ocean. Can you think where all the salt comes from?"

"No," said Frank. "There is no salt around here for this river to carry."

"I will tell you something," said Uncle Robert. "Almost all earth contains a little salt which the rain-water dissolves."

"But there isn't any salt in this river," declared Donald. "This is fresh water."

"There is a little salt in every river," said Uncle Robert. "The particles are dissolved by rain-water and carried into the rivers in solution. Then the rivers carry the salt down to the sea."

"Is that the reason the ocean is salt, because all the rivers carry down a little?" asked Frank.

"That is said to be the reason," said Uncle Robert. "The heat of the sun evaporates the water from the ocean, but there is no salt in this vapor."

"So the salt is all left," said Donald. "Now I know why the sea is too salt and the rivers not quite salt enough."

## CHAPTER VII

### CLIMBING THE HILL

FROM the time the boys had their first view of the long hill called the Rib they were anxious to climb it. It was the highest hill they had ever seen. They wondered what could be seen from the top of it.

"We will make the trip to-morrow," said Uncle Robert.

"Let's start early," said Frank, "and take our lunch."

So the next morning a little after sunrise they rowed across the river. The current was so strong that in spite of all they could do the boat would slip down-stream. There were islands to row around too, and they had to make a wide curve to reach the shore nearest the hill. They tied their boat, cut some sticks for canes, and began to climb the long sloping ridge. The end of the ridge nearest the river sloped very gradually. It was nearly covered with trees. Great rocks cropped out here and there. The surface was made up chiefly of gravel, boulders, and pieces of rock with sharp corners. What soil there was on the hill was very thin.

Donald picked up some stones and handed them to Uncle Robert.

"They are like those we found on the steep bank back of Mrs. Lilly's farm," he said. "What are they?"

"Some of these are granite and some are gneiss, I think," said Uncle Robert. "It is hard to tell one from the other in such small pebbles. They are composed of about the same minerals."

"What are the minerals?" asked Frank.

"The principal minerals in both granite and gneiss are quartz, feldspar, mica, and hornblende. There are many varieties of both rocks which contain other things in small quantities."

"If they are made of the same minerals, why aren't they the same rock?" asked Donald.

"The difference is in their structure—that is, in the way these minerals are put together. Look at this big boulder. It is a coarse granite. These clear glassy-looking particles are the quartz. The pink is feldspar and the black is hornblende. I can not see the mica in this, but I have seen granite containing mica in sheets as large as writing-paper. Mica is used in the doors of hard-coal stoves."

"Oh, it looks something like glass," exclaimed Donald. "Is that a mineral?"

"Yes, that is mica."

"Do you see any boulders of gneiss?" asked Frank.

"Not here. Let us go on. I will look for one."

They climbed on slowly. Soon Uncle Robert



stopped before a large gray boulder with dark bands running around it.

"This is gneiss," he said. "You see that it is finer in grain than the granite, and the different minerals of which it is composed seem to be arranged in layers or thin bands."

They went on up the hill. The air was pure and fresh. The sun shone brightly. As they came near the top of the ridge they found some sharp ledges of bare rock. They were as straight up and down as a wall.

"These are precipices," said Uncle Robert.

"See that tree growing downward," said Donald. "I don't see how it can grow in the rock with no soil."

"The roots of trees have a wonderful power to grow into rocks," said Uncle Robert. "They find tiny cracks and crevices, and as they keep on growing the cracks and crevices are made wider, just by the strength of the tender roots."

At the foot of one of the precipices they saw a pile of broken rocks, with bushes and trees growing upon it. The top of the precipice looked rough and broken.

"How do you think that slope was made?" asked Uncle Robert.

Frank looked at it carefully and said:

"It looks to me as if the rocks and earth had broken off that cliff up there and fallen down."

"Did the roots break them off?" asked Donald.

"They may have had something to do with it. Then the water ran into the cracks, froze, expanded,

and broke them still more. In the spring they came tumbling down to the foot of the cliff. Can you see how, if this keeps on for a long time, that cliff will be made into a slope?"

Frank took his paper and drew a profile of it. (Fig. 6.)

"I see," he said. "First we have a straight, steep cliff. A little of the top breaks off and falls to the foot of the cliff. Then more and more breaks



Fig. 6.

off and falls. This cuts the cliff back at the top and builds it out at the bottom, until after a long, long time we have a slope."

"That is the way many steep cliffs are changed to gradual slopes. Indeed all cliffs in time develop talus slopes."

When they reached the highest part of the hill they had the finest view. They could see the river winding like a thread of silver among the hills. In the valley lay the city surrounded by low rounded

hills. Some of these hills were covered with trees, while others were quite bare, as though the trees had been cut off. With the glass they could see a long distance. Not far away they saw another hill, smaller, but much like the one they were on.

"That is called the Little Rib," said Uncle Robert.

They sat down in the shade of some pine-trees, while Donald looked about to see what kind of birds live away up there all by themselves.

After a while Uncle Robert said:

"Well, boys, can you tell me what you have seen? Have you any questions to ask?"

I noticed that some of these boulders are different from the rock in this hill," said Frank. "I should like to know how they came here. The boulders are rounded, but these other rocks, which are like the solid rock of this hill, are flat and sharp-cornered."

"The pebbles up here are like the pebbles I found in the gully," said Donald.

"You told us that this hill was once very much higher than it is now," said Frank. "I should like to know how that could have been."

"Yes," said Uncle Robert. "It may have been a great mountain with a sharp peak."

"And now it is a hill with a rounded top," said Donald.

"I am sure that is a problem that we boys can never solve," said Frank. "How a high mountain was made into a long, low ridge."

"I give it up," said Donald.

"I think we can hardly solve it by ourselves,"



said Uncle Robert; "but we can have help from others who have studied the same problem. There are many hills and mountains just like this scattered all over the northern part of North America and Europe. I have read some of the books written about them by those who have studied them before us, so I can help you a little.

"First, we must know something about the rock that we see cropping out all around us. What is the difference between this rock and that down by the spring at home?"

"The rock at the spring is limestone," said Donald, "but this isn't."

"How do you know it is different?"

"The limestone is in layers," said Frank, "and this is not."

"Yes, and rock that is in layers we say is stratified."

"There is a difference in the color, too," said Donald.

"The limestone is all of one color, a grayish white," said Frank; "but there are ever so many colors in this rock."

"Stratified rocks, such as limestone, were made on the bottom of the ocean."

"Oh, I remember you told us that before," said Frank. "You said that one way this is known is by the fossils in the rock."

"I know what a fossil is," said Donald. "It is an animal or fish or some such thing that died and its bones were buried in the rock."

"Where did all the material come from to make the rock?" asked Frank.

"You remember what I said about the earth carried into the ocean by rivers?"

"Oh, yes. You said the salt and lime are in solution. Does that lime in solution help make the limestone?"

"Yes. It is taken from the water by the little animals whose fossils are found in the stone. Some limestone is made almost entirely of fossils; some has no fossils at all."

"I don't see how all that mud and sand which the river carries can ever become hard rock," said Frank.

"It is soft mud at first, but after a time it changes to solid rock."

"What changes it?" asked Donald.

"Well, the heat in the earth has much to do with it and also the pressure of one layer upon another."

"But how was this rock made? It is not in layers or—stratified, did you call it?"

"Yes, stratified."

"Are there fossils in it?"

"No, there are no fossils in it. I will tell you, boys, that I do not know just how this rock was made. There are many theories about it, and I can tell you some of them."

"What is a theory?" asked Donald.

"We had a theory of how the flood plain was made."

"We found out all about how it was made," said Frank.

"I'm not so sure of that," said Uncle Robert. "We may have overlooked some very important point. It is never safe to say we know all about anything. Men who study these subjects do not know all about them at once. They find out one thing after another. Then they put them together as a foundation upon which to work out their problems. Often one man thinks he has found something to be true; then some one else studies a little more and proves the first man's theory to be false.

"Now I can tell you several theories of how this rock was made. When you look through the glass you can see the same kind of hills for miles around. If we should dig through this thin soil we would doubtless find the same rock, and as we go down the river we shall see it cropping out all along the way.

"About a hundred and fifty years ago a theory of how the first rock was made was proposed by Kant, and worked out more fully later by Laplace. They thought that rock like this was made by the cooling of fine particles, called fire mist, in the air. Some astronomers think that the Milky Way, which we often see at night, is made up partly of this fire mist or vapor. You remember I told you the cooling of water vapor in the air condenses it into rain. The theory of Kant and Laplace is that this fire mist cooled gradually, and at last became solid rock, and so formed the original crust of the earth. It was thought that gneiss, granite, and some other rocks were made in this way.

"Another theory is that this first rock, which is



called archæan, because archæan means oldest, was once held in solution in the ocean. The ocean was very hot, and as it cooled solid particles gathered and fell to the bottom. There they were formed into one mass of solid rock."

"Which theory do you think is the true one?" asked Frank.

"I think we can hardly decide on the true theory of how the first rock was made," replied Uncle Robert; "but there are other theories about the age of the different kinds of rock and the ways in which rocks are now being made. I have told you how rock is formed from matter deposited in the ocean. There is another way. You have read of volcanoes?"

"Oh yes," said Donald; "fire and lava come right out of a mountain."

"Yes. I have told you of the great heat deep down in the earth; a heat so great as to melt rocks such as these. The crust of the earth breaks open and great quantities of this melted stone are forced out. It spreads out over the surface and piles up into high masses, and when it is cool it is very hard rock. Now if this melted rock did not come to the surface, but cooled deep under the earth, the pressure upon it may have made it different from the volcanic rock."

"What would there be to press on it?" asked Frank.

"How much do you think this hill weighs?"

Donald laughed.

"We haven't any scales, so we can't weigh it," he said.

"Well, that little boulder over there. How much does it weigh?"

Donald tried to lift the boulder, but he could not move it.

"The hill must be very heavy," said Frank.

"Yes, it presses down very heavily on the rock below."

"Oh, I see what you mean by pressure," said Frank. "But rock can't be squeezed any smaller, can it?"

"Yes, if there is weight enough placed upon it."

"I should think it would break into pieces," said Donald.

"It does when the pressure comes upon it too suddenly. But under steady pressure it can be changed without breaking."

"How many ways of making rock have I told you about?"

"You have told us about the material laid down by rivers in the ocean-bed," said Frank, "and about limestone."

"And about the melted rock thrown out by volcanoes and cooled," said Donald.

"Yes, and the melted rock that has cooled under ground. This and the volcanic rock are called igneous rock," said Uncle Robert.

"What does igneous mean?" asked Frank.

"Igneous means made by fire. The rock laid down in the ocean in layers is called stratified rock. This rock at the top of the Rib is igneous rock."

"How does it come to be here if it was formed deep under the earth?" asked Frank.

"All the land was once under the ocean; the ocean spread over the whole earth. Then part of the land rose above the water and slowly became high mountains."

"And you say that this hill we are on was once very much higher than it is now?"

"Yes, and the problem for us to work on now is, how was it changed from a high mountain to a hill."

When they had eaten their lunch they wandered down the hill on the opposite side from the one they had climbed up. The hill widened as they went down and in many places were great masses of boulders, gravel, and sand spread out like fans. In some places the solid rock was quite bare. Frank discovered that there were long scratches on the rock, and that they all ran in the same direction.

"See," he cried, "it looks as though some one had taken a file and dug into the rock."

"What could have done it?" asked Donald.

"That is part of the problem," said Uncle Robert.

"It must have been something very heavy and very hard to scratch that rock," said Frank.

In going back to the tent they went through the woods around the foot of the hill instead of over the ridge. As they rowed across the river they voted that it had been a fine day.

## CHAPTER VIII

### LETTERS

"WE'D better write our letters now," said Uncle Robert when supper was over.

"I'll answer mother's letter," said Frank. "It was just like mother to write such a long letter so soon."

"Isn't it funny," said Donald, "for Susie to watch the thermometer and barometer every day so that she can tell us about them when we get home?"

"I'd like to see some of the pictures she has painted," said Frank.

"We'll see them when we get home," said Donald. "You know mother said she writes the date on every one when it is done."

"I hope we'll have some good pictures to show her," said Frank.

"We'll have some stories to tell her, too," said Uncle Robert. "But can't we tell her some of them before we go home?"

"You write to Susie, Donald," said Frank, "while I am writing to mother."

"But I don't know what to tell her first."

"You remember you were going to write to her about the sawmill," suggested Uncle Robert.



"Oh, yes. I'll write that this evening."

So they went out on the bank where the breeze would keep off the mosquitoes and sat down to write their letters.

Here is Donald's letter to Susie:

DEAR SUSIE:

We were glad to get mother's letter. We are a long way from home, but we are having a very jolly time. We have been on a long tramp to-day to the top of a high hill, across the river. You never saw such a high hill. I thought it was a mountain, but Uncle Robert says it isn't. But what do you think? Uncle says it was a very high mountain once, and something cut the top off. Isn't that wonderful? I can't imagine what could have done it, for it is made of the very hardest kind of rock there is in the world. There are some boulders like it on our farm. I will show them to you when I come home.

But I can't write any more about the hill, because I want to tell you about the sawmill. I saw a log that was once a big pine-tree. I counted the rings in it. It was a hundred and sixty years old. It was three feet across the largest end. They sawed it into boards, and it took only a few minutes to do it. But I'll begin at the beginning.

We went to the top of one of the hills. There are hills all around the city. Frank took a picture of the city, and it shows the high hill I told you about, so you can see just how it looks when we come home. When we were on the hill we discovered the saw-mills. Then we knew what kind of place Wausau is. It is a lumber city. I wanted to see the saw-mills, so we went. It was great fun to see them work.

First there is a place in the water where they keep the logs. It is where the river is spread out by the dam. There were many logs in it: big ones and little ones. They are kept there by a boom which is made of logs fastened together. A man with a long pole that had an iron spike on it stood by and turned the logs toward the mill. He made them go up a little slope, where they caught on a big flat chain that moved round and round. The man called it a bull chain. This chain dragged the logs up an inclined place where they were to be sawed. Another man stood there and turned one log one way and another the other so they would go to the saws.

There are two kinds of saws to cut the logs into lumber. One saw is a circular saw. It is a great round plate of steel, with teeth all round the edge. It turns very fast and cuts right through the log from end to end. The other is a band-saw. This is a broad band of thin steel with teeth on one edge. It turns round two pulleys, one low down and the other up near the ceiling.

The man sent the best logs to the band-saw, because it is thinner and doesn't cut away so much of the log. I wish you could have seen the big pile of sawdust that the circular saw makes.

After the logs were cut into boards, they ran out on a place that moved like the bull chain. A man stood up there with what Uncle Robert called a lever. He watched the boards as they came up and cut them off by just moving the lever. He cut them into different lengths. I don't know why, but he seemed to know all about it. Some more men stood by, and as the boards were cut they sorted them and loaded them on wagons. They took the lumber out and piled it into great piles.

We saw them making laths and shingles, too. The poorest timber and the slabs that are cut off the lumber logs are made into laths. A machine does all the work. Then a man counts them and ties them into bundles. Another machine makes the shingles. A man cuts them the right size. He seemed to know just by looking at them. Uncle Robert says he has a trained eye. I looked at his eyes, but they didn't seem any different from any other eyes to me.

The most of the lumber is of pine. The hardwood is cut in the winter. They can't float it in the river because it is so heavy it sinks. So they bring it down on the ice.

You just ought to see the stumps up here where they have cut the trees to make lumber. I don't see what they will do when all the trees are gone. We asked Uncle Robert, but he couldn't tell either. You wouldn't like the stumps. They are not a bit pretty. It seems too bad to cut down all the trees; but I suppose people must have lumber to build houses with.

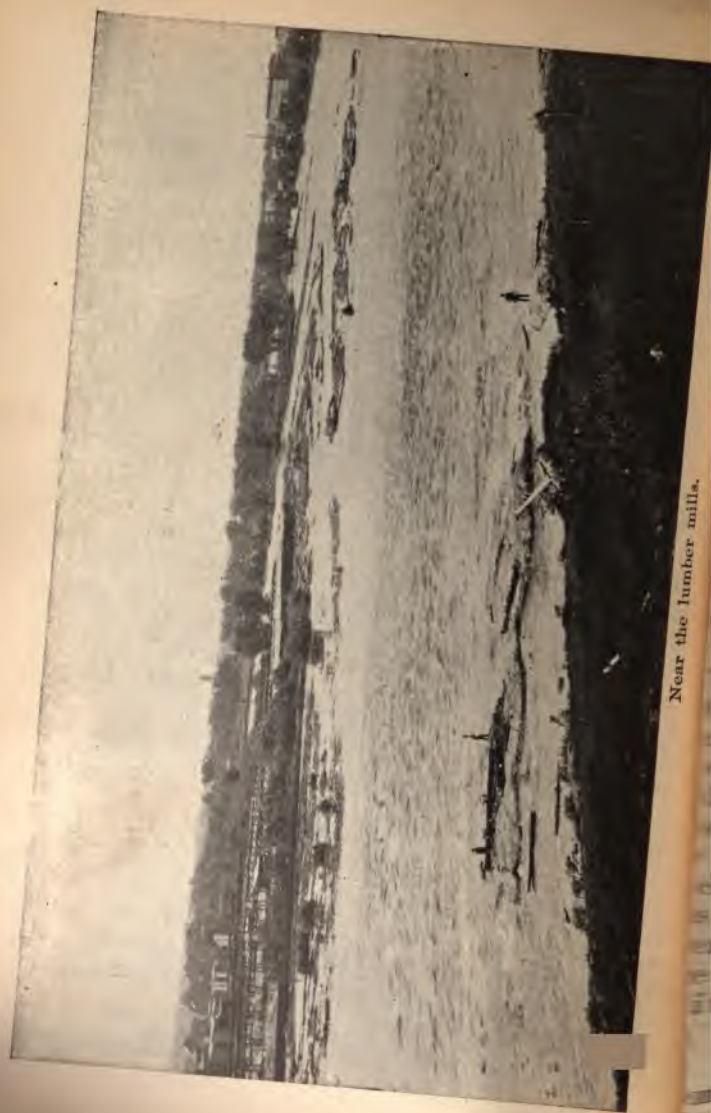
We are having lots of fun. I do the cooking, but I am afraid I shall never be as good a cook as mother. You can't think how much we eat! We get milk and eggs from Mrs. Lilly. I don't know where we shall get them when we go on down the river. We are going to start soon.

I wish you and Barri were with us. I am glad you are watching things. If it rains, don't forget to look at the rain-gage. Frank is writing to mother, and he will tell the rest. It is getting dark, so I can't see to write any more. The mosquitoes are dreadful. Give my love to mother, father, and Barri, and Jane and Peter.

From your loving brother,

DONALD.





Near the lumber mills.

Frank's letter was as follows:

DEAR MOTHER:

We were so glad to get your letter. We meant to write before, but we have been very busy. To-day we had a long walk away to the top of a high hill, which we can see from here. It is called the Rib. It looks more like a mountain than a hill, and the strangest thing is that Uncle Robert says that once it was a very high mountain. I don't see how anyone could ever know that unless he saw it, but Uncle Robert says it is many thousands, maybe millions of years since it became a hill, and I suppose there were not many people living here then. None of them is alive now if there were. But we are going to try and find out about the hill. I believe Uncle Robert knows, but he wants us to work it out for ourselves. He tells us stories that help us, and I like to work the problems.

To-day he told us about the rock. Just think, another, one time all the world was covered by the ocean. There was no land to be seen, or if there was, it was only a little. Then some way or other the land came up out of the water. This rock looks like some of the boulders on our farm. It isn't at all like the limestone at the spring. That is stratified, which means in layers, and this is not. The minerals in this rock are all mixed together, and the rock is very hard. We have been working problems ever since we came, and the more we do it the better I like it. We have found out just how the land in this farm was made. It is something like our cornfield, only the spring floods never cover it now. Uncle Robert says they used to a long time ago.

There is a steep bank just back of the farm. It

does not slope so much as our hill. Then there is a plain and another little bank; then another plain between that and the river. The river is cutting into the bank on this side now. Mrs. Lilly says it has cut away about forty feet since she has lived here. If it keeps on the whole farm will go. I told her so, but she only laughed.

All the plain from the river to the steep bank was made by the river. Just think of that, mother! The river cut away other land far from here and brought it down to make this farm. It is ever so much better for farming than that back of the high bank. It is like our cornfield.

Uncle Robert says the high bank was made in some way, too. We have not found out about it, but we know the river didn't do it. It is just as plain how the river made this farm. I have some drawings—profiles, Uncle Robert calls them—that show how it was done. I will show them to you and tell you all about it when we come home. I have taken some pictures, but we shall not know if they are good until we get home and develop them. I bought my camera just in time, didn't I?

We have seen a great many things and are having the best time I ever had in my life.

This would be a beautiful country if it were not for the stumps. There must have been a great forest here once, but the trees have been cut down to make lumber. We went to the sawmill to see how lumber is made. Donald is writing to Susie about it. I hope I can tell you about the hill in my next letter. That is our next problem.

Have the thrashers come? I hope they will not get there before we are home. We saw a farm here where they were thrashing as we came along on the



I haven't seen a farm that I like as much as I  
ours. We saw a great many lakes. Donald says  
wishes we had a lake, but I like our river best.  
river is bigger than ours, and flows a great deal  
er.

Uncle Robert and Donald send love to you and  
er and Susie. So do I. It is dark now, and I  
t stop. The mosquitoes are terrible.

Your affectionate son,

FRANK.

## CHAPTER IX

### GLACIERS

THE next morning after the housekeeping or tent-keeping was done, they sat upon the bank of the river. Frank looked long at the hill which they had climbed the day before. Then he turned toward the steep bank that rose back of the old flood plain.

"What are you thinking about?" asked Uncle Robert.

"I think we have the biggest problem of all," replied Frank, "to find out how that hill was worn off, and how that gravel-bank came there."

"Are you sure the river didn't do it?"

"Uncle Robert, I can't see how it could be possible for a river to flow over the top of a high mountain and wear it off. It might have brought the gravel-bank, but it is very different from this land here."

"In what way is it different?"

"Well, there are big boulders in the gravel and the pebbles are larger and rougher. Then the sand and gravel and boulders are all mixed together. It isn't at all like what you called river drift."

Donald had been sitting on the bank arranging his collection of stones.

"Come and see!" he shouted. "I have all kinds of pebbles here."

He had placed them in little groups. Some were white, some were nearly black; others were red, and others green. There were gray pebbles with little black streaks in them, and brown ones and pink ones. Some were almost as round as marbles, and some were egg-shaped.

"Aren't they pretty?" said Donald. "I'm going to take them home to Susie."

"I wonder where they came from and how they were made," said Frank, thinking of what Uncle Robert had told them the day before.

"I found them all in the gully, there are thousands of them," said Donald.

"Let us go up there, and see if we can learn more about them."

Donald gathered up his pebbles. Then they started off, carrying the camera and the field-glass. When they reached the gully Donald began to collect more pebbles.

"Let us make an experiment," said Uncle Robert, "and see how many different kinds of minerals we can find in five minutes. You pick them up, Donald, and give them to me. Frank, you take the paper and pencil. When Donald gives me a stone I will tell you its name if I know it, and you write it down. Now begin, Donald, and try not to take two of any one kind."

In five minutes they had the following list of stones:

- 1 Syenite, feldspathic, red granite.
- 2 Syenite, hornblendic, gray granite.
- 1 Syenite, pink, pink granite.
- 5 Ferruginous quartz, 4 distinct specimens.
- 1 Brown flint.
- 2 Sandstone (Lake Superior).
- 2 Shale.
- 1 Hematite.
- 1 Rose quartz.
- 1 Milky quartz.
- 1 Serpentine.
- 1 Mica schist,
- 1 Gneiss.
- 1 Gray sandstone.
- 1 Diabase.
- 1 Diorite.
- 1 Jasper.

"How many do you suppose you could find if you worked all day?"

"Oh, hundreds of them," said Donald. "And the boulders are all of different kinds, too."

"They can't be river drift," said Frank, "for the river pebbles are smaller and smoother. Many of these have rough, sharp edges. There is not so much coarse gravel in the river drift that we examined as there is here."

They climbed up the steep slope and looked **away over** the level surface. On the side of the river

opposite them lay the Rib, over which they had taken their trip the day before. A little way off lay the Little Rib, smaller, but looking much like the Rib.

"This level land seems to be made of gravel and sand and boulders, just like the slope," said Frank.

"You think the river could not have made this great mass of land here?"

"I don't see how it could," said Frank. "It is very different from the land below the slope."

"Do you think these stones could not have been made here?" asked Uncle Robert.

"I think all these pebbles and boulders came from different places," said Frank. "They couldn't have come from one place, because there are hundreds of different kinds."

"But there are a great many kinds of rocks up on the Rib," said Donald.

"Yes, and a good many different kinds of pebbles might come from the same mass of rock," said Uncle Robert.

"I think these pebbles came from a great many different places," said Frank.

"How did they get there?"

"That is what puzzles me," said Frank. "What could have brought them if the river did not?"

"How far do you think these pebbles and boulders might have come?"

"I don't know," said Frank. "We should have to search all around here for miles to find out."

"The main question," said Uncle Robert, "is to find out what cut that hill down. I think we can



not solve the problem alone, for it is one upon which a great many learned men have worked for years. I have seen the man who first solved part of the problem. He was a great teacher."

"What was his name?" asked Donald.

"His name was Louis Agassiz. He was born in Switzerland. He lived and studied in the fields and woods and mountains. He came to this country to teach. Let us sit down under this tree, and I will try to help you to solve the problem by telling you what little I know about it.

"I wish I might take you far away from here into the high mountains. I should like to have you see the sharp, rocky peaks towering up into the sky and the steep slopes cut in many places into deep cañons and gorges."

"We have seen pictures of mountains like that," said Frank.

Uncle Robert pointed to a bank of billowy white clouds lying low along the horizon.

"Can you imagine that pile of clouds," he said, "to be a distant range of mountains, capped with snow?"

"It does look a little like a picture in a book we have at home," said Donald. "Do mountains covered with snow really look like these clouds, Uncle Robert?"

"They are not unlike. I have often mistaken clouds hanging low along the horizon for distant mountains. But now I want you to think, if you can, that we are in the mountains. We are going up

through one of the deep cuts in the mountainside. Here straight bare walls of rock rise hundreds of feet on either side of us. This is a cañon or gorge. Now we come out of the cañon into a broad open space, where the gently sloping surface is covered with trees and grass. This is a mountain valley. In the Rocky Mountains such a valley is often called a park. Beyond the park the ravine becomes narrow again, but the mountains are not so steep as in the cañon, and are covered with pine-trees. Sometimes the bottom of the ravine is rugged and steep and hard to climb. Then it seems almost level, but it is not.

“Up, up we go, here and there catching wonderful views through other ravines which open into the one we are climbing. At last trees and grass are left far behind. The rocks are here. We look down and see clouds hanging below us. We look up. What seems to be a cloud lies above us. We go on, and find that which is above to be snow. It is very cold. All over the mountainsides the snow lies deep and white and still. Some of the peaks above are so steep that even the snow can not cling to their rocky surface. Their heads rise dark and bare above the white mantle that settles down about their shoulders. Summer and winter, year after year, century after century the snow lies here. During the summer days the hot sun melts its surface, but the nights are cold and it freezes again. More snow falls. The heads of the ravines become filled. The sides of the mountains are covered deeply. The weight of the snow is very great.

"Suddenly a noise like thunder echoes among the silent peaks. Then all is silent. But the mountainsides where the snow lay so heavily are bare. In the valley below lies a great mass of snow filled with rocks and earth that the snow has carried with it."

"Oh," interrupted Donald, "that is an avalanche. You told us about the avalanche in the Pass of St. Bernard, where Barri came from."

"Sometimes whole villages are buried under the avalanches," said Frank.

"Does the snow always take rocks and earth with it?" asked Donald.

"Usually. And sometimes the rocks and earth fall down without the snow. This is called a landslide. A mass of snow or even a small pebble may start either one of them."

"How could a little pebble do such a thing?"

"A little pebble far up in the mountain may become loosened by the frost. It starts to roll. Another one joins it. The two start three, and so on until a great mass of earth is rolling and thundering down the mountainsides, crushing forests and hurling all far down into the valley below. Up in the Tyrol Mountains I have seen little fences three or four inches high, made of withes, placed all over the sides of the mountains. Before a pebble rolls far the fence catches it, and so prevents the landslide.

"But we were looking at the great mass of snow lying in the heads of the ravines. For many, many years it has been lying there, growing thicker and



deeper and heavier. As it melts under the hot sun of summer and freezes through the long cold winter, melting and freezing, melting and freezing, the soft snowflakes gradually turn into little grains of ice. The great weight of the ever-increasing pile of snow presses these little grains together. They became harder and more compact until they are one solid mass of ice. You have made snowballs and know how it is done."

"If we pack our snowballs very hard they turn to ice," said Frank.

"And so it is with the snow that lies in the heads of the ravines upon the mountain tops. As the weight upon it becomes heavier, it is packed harder and harder.

"Now it has been proved by people that have made a great many experiments that ice under great pressure moves. They used to say 'flows,' not as water does, but as tar or some very stiff substance will. They say now that they are not sure about its flowing, but it is certain that it moves. There are many theories as to the cause and manner of this movement, but it is enough for us to know that under great pressure ice moves.

"We have seen that there is a great pressure upon the snow-ice which has been lying upon the mountain tops for so many, many years; it may be hundreds, it may be thousands of years. This pressure is from the great depth of the snow as it has fallen year after year. It is also from the mass lying higher up on the slopes pressing downward upon that which lies

below. The high peaks press it together from the sides. Only the ravines are open.

"At last the mass of snow begins to move. Not as the avalanche, with one mighty rush, carrying all before it, but slowly, slowly, it creeps down the ravine. Where the slope of the bed is very slight it moves so slowly that we are uncertain whether or not it moves at all. When the bed is steep it advances more rapidly; its surface is broken and rugged, the ice is seamed with cracks and ridges. These cracks are called crevasses, and sometimes they become very wide and deep. On goes the ice down the ravine until it reaches the valley at the foot of the mountain. Even there it does not stop. It spreads out over the green fields and even the trees; grass and flowers disappear before it. Then it goes no farther. Something has stopped it. The river of ice that has made its way from the vast snow-fields upon the mountain top, down through the sloping ravine, out into the valley below, has turned into a stream of ice-cold water and flows on over the plain to make its way to the sea."

"I know what you are telling about," said Frank, who had listened intently to the story. "It is a glacier. I have read about glaciers. I wish I could see one."

"Father told us about the glaciers where Barri came from," said Donald.

"Yes, there are many glaciers in the Alps, but they are old now. They are much smaller than they were once. And now can you think of the glacier





A glacier of the Cascade Range in northern Washington. Though it is August, the higher parts are covered by snow and there are banks of snow farther down. The lower end is surrounded by a curving terminal moraine.

whose growth we have watched, as having stretched from the snow-fields upon the tops of the mountains, down into the valley for hundreds and hundreds of years?"

"Do you mean just lying still all that time, Uncle Robert?" asked Frank.

"It would look so, but really it has been moving all the time. It has not moved as a solid mass. The sides have moved more slowly than the middle, and the ice on the surface has moved faster than that next to the bed over which it moves."

"That is like the current in a river," said Frank.

"Yes. There is a current in a glacier, too, and it moves from side to side much as the current of a river does. The manner in which a glacier moves was discovered by the great teacher Agassiz, of whom I told you."

"How did he find out about it?" asked Donald.

"He drove a row of stakes in a straight line across a glacier. In a few days he found that the middle stakes had moved farther than those on the sides. The row of stakes formed a convex curve downward."

"Then the middle of the glacier moves faster than the sides," said Donald. "Why is that?"

"Because the rocky walls of the ravine hold the sides back. It is just so with the bottom. The ice on the bottom is held back by the rock over which it passes."

"How white and beautiful a glacier must be!" said Donald.

"Some glaciers are very beautiful in the sunlight,"

replied Uncle Robert, "but often they are covered so thickly with sand and gravel and boulders that the ice can not be seen."

"But how does all this stuff come to be on top of the glacier?" asked Donald.

"You remember the avalanches and landslides?"

"Do they slide down the mountains and upon the glacier?" asked Frank.

"Yes, but what an avalanche or landslide does in a large way is going on all the time. Rocks and earth are constantly rolling down upon the glacier, especially in the spring, when the frost comes out of the ground and loosens them. So the glacier gathers upon its surface rocks and earth. And as it moves along its course it freezes down upon the loose material in its path and carries it along. Pebbles and rocks frozen solidly in the mass of ice act as cutting tools, and grind and gouge the surface over which the glacier passes."

"I think a glacier must do a great deal more work than a river," said Frank; "and we know a river can wear away solid rock."

"As we look upon the glacier filling the ravine we can not see the grooved and polished rock beneath. It is after the glacier has gone that we may see this. Then it is possible to tell just the direction in which the glacier has moved by the long scratches in the rock all cut in one direction by the rocky tools which the glacier carried. These scratches are called *striæ*."

"Oh, Uncle Robert," exclaimed Frank, "do you

remember the scratches I saw on the rock up on the Rib? Could they have been—what did you call them?"

"Striæ," said Uncle Robert.



Bed-rock scored with glacial marks, near Amherst, Ohio.

"Striæ?"

"But no glacier ever went over that mountain," declared Donald. "I want to know about the material the glacier carries."



"As we look upon the ice," said Uncle Robert, "we see that it is striped with dark bands of earth and rock. These bands lie like ribbons along the edges, and often through the middle of the glacier. They are formed of the rocks and earth that have fallen down the mountains or have been worn off the rocky walls."

"How did they get away out into the middle of the glacier?" asked Frank.

"Do you remember the tributary ravines we saw as we climbed to the top of the mountain? Through these ravines other glaciers have come, and joining the main one, have become tributary glaciers."

"Just as a river has tributaries?" said Frank.

"Yes, with this difference. As you know, the water of a tributary river mingles with the main river, and is soon lost sight of. Not so with a tributary glacier. It does not mingle with the main stream. It moves along by its side. Then the bands of earth and rock that bordered both the tributary and the main glacier above the place where they met are carried along in or near the middle of the stream of ice.

"These bands of rock and earth carried by a glacier are called moraines. When they are on the sides they are called lateral or side moraines. When they mark the inner surface of the ice they are called medial or middle moraines."

"The dark streak down the middle of the glacier after the tributary joins it is a medial moraine, isn't it?" said Frank.

"Yes, and a medial moraine may be formed in



another way. A hill or mountain may stand in the ravine down which the glacier is moving. Then if the glacier is not big enough to go over the top of the mountain, it separates, and part goes to one side and part to the other. As it moves on it grinds off the sides of the mountain. Then when the mountain is passed and the parts unite again there is a moraine in the middle to tell of the work the glacier did grinding away the mountain that stood in its path."

"Are the moraines very thick?"

"They are often thick enough to protect the ice from the heat of the sun and keep it from melting as fast as that which is uncovered. This makes the moraines stand up like ridges with ice valleys between them. But rocks and earth are constantly falling from the ridges into the valleys, and in this way the moraines spread. The glacier moves on with its load, and by the time it reaches the valley below the ice is often covered to a depth of several feet with rocks and earth. In Alaska there is a forest growing in a moraine on the top of a glacier."

"A forest growing on ice!" exclaimed Donald. "Isn't that wonderful?"

"It seems to me that a glacier can carry a great deal more than a river can," said Frank. "Does it carry all of its load on top of the ice?"

"No; earth and rocks are mixed all through it."

"How do they get into the solid ice?" asked Donald.

"Do you remember the great cracks or crevasses

of which I told you?" Some of these crevasses reach across the glacier and are very wide and deep. Others are in the sides. Great quantities of the moraines that lie on top of the glacier fall down into the crevasses. As the glacier moves along, the cre-



A crevasse.

vasses close up and the rocks and earth are frozen into the ice. If the crevasse is deep enough they go through the glacier and are carried along beneath it. Then they become part of what is called the ground moraine, which is the ground-up rock carried beneath the ice. There is another way in which a great many boulders are buried in the glacier. As they roll down

from the moraines upon the clear ice, they become heated by the sun shining upon them. Then they melt the ice beneath them and sink down far below the surface."

"If the ice melts very fast it must make lots of water," said Donald.

"So it does, and the water runs everywhere."

"Like rivers on top of the glacier?"

"Yes, and it pours down through the crevasses and makes rivers under the ice, too."

"Is that what makes the river that flows from the end of the glacier?"

"Partly. Many rivers have their sources in glaciers. But now let us look at the end of the glacier. Here is a wonderful ice arch into which we may go for a short distance. Overhead the ice is a clear blue. At our feet flows the ice-cold stream. The water looks thick and gray with the ground-up rock which it carries. This tells us, as nothing else can, of the work that is going on under the ice. But what do you think keeps the glacier from spreading farther out into the valley?"

"It is warmer in the valley than it is upon the mountains," said Frank. "Perhaps the ice melts."

"Yes, the ice melts. It is the heat of the sun that holds the glacier back."

"But the rocks and earth in the ice don't melt," said Donald. "What becomes of them?"

"They are dumped down at the end of the glacier. This makes the terminal, or end moraine. It is often



called a dump moraine. The terminal moraine is a great pile of gravel, sand, and boulders all mixed together. It is the largest of the moraines, for all the earth brought to the end of the glacier is dumped into it.

"After a while comes a much warmer time than that when the glacier pushed its way so far out into the valley. The end of the glacier draws back before the heat. As the ice melts, the earth is dropped in a long ridge. Then it grows cold and the glacier pushes its way out into the valley again. The dump moraine is carried before it and is heaped up in a great mound. Again and again a period of warmer years comes, to be followed by a period of cold, and the glacier draws back or pushes out as the climate changes. These changes occur over and over again."

"Does the dump moraine keep on growing bigger and bigger?"

"It is often very large. It would be larger but for something which carries much of it away."

"Is that the river which flows from the end of the glacier?"

"Yes; this stream carries away a great deal of sand and gravel and the ground-up rock which is called boulder clay. This clay is ground as fine as flour is ground in a mill."

"Well, I never heard of such a mill as a glacier!" said Frank. "It beats the river at grinding."

"Can you think what a glacier is like now?" asked Uncle Robert.

"I can almost see one," said Frank.

"So can I," said Donald. "Oh, wouldn't I just like to see one grind!"

"It is with the glacier much as it is with the river," said Uncle Robert. "You can see very little that it is doing, but you can see much that it has done."

"It seems to me that a glacier works a great deal as a river does," said Frank.

"It brings down earth and grinds up the rocks," said Donald, "but it doesn't build flood plains."

"And a river doesn't make moraines," said Frank.

"What do you think would happen if the climate should grow very much warmer and stay so for a long time?"

"The glacier would all be melted."

"Would a river flow in the valley where the glacier was?"

"Very likely. But along the sides of the valley we should find the lateral and ground moraines left by the glacier, and where the rock was bare we should find it scratched and polished from the rock-shod ice that had passed over it."

"I wish I could see a glacier," said Donald.

"I hope you may see one some day," replied Uncle Robert.

"And I wish I could see a place where a glacier has been," said Frank.

"You may see that right here all around you," said Uncle Robert.



## CHAPTER X

### THE GREAT ICE-CAP

THE boys were eager to hear more of the story of the glacier.

"Please tell it now, Uncle Robert," said Donald. Uncle Robert looked at his watch.

"It is the time we had set to break up camp and go on down the river," he said. "Would you rather have the story now and stay here a day longer, or go on and hear it at our next camp?"

"Let's wait," said Frank. "I want to see more of the river, and the story will keep."

"Yes," said Uncle Robert, "it is a good day to move camp, and I'm in favor of going."

So they went back to the tent, and in a very short time had all their baggage packed into the boat, said good-by to Mrs. Lilly, and were floating down the river.

Their next camp was on a beautiful island. The little tent was set up under a wide-spreading elm-tree. They explored the island, and found the only inhabitants to be rabbits, squirrels, and many birds. These were all very wild and looked with surprise and some alarm upon their new neighbors. The

rabbits scrambled into the thickets at their approach; the squirrels whisked up the tallest trees, and the birds took wing and flew away before Donald could discover if he knew them or not.

At last they sat down under an elm-tree. Then Frank said:

"Now, Uncle Robert, please tell us more about the glaciers. I can see how they cut the deep gorges of the mountains, but I can't see what glaciers have to do with this country. Glaciers come from the tops of mountains, and there are no mountains here, except the Rib, and surely it was never high enough for the snow to stay on it all the time."

"There was once a great glacier right here where we now are."

"Then there must have been mountains," said Donald. "But what has become of them?"

"I will tell you the story, and then you can decide that for yourself. Do you see this long flat piece of stone?"

"Yes," said Frank. "It has marks on it just like those we saw on the rocks up on the Rib. Are they the same kind of marks you said were made by a glacier?"

"Yes, they are glacial scratches or *striæ*."

"Oh, yes, that's the name," said Donald; "*striæ*. You said it was the sharp pieces of rock in the ice that made them, didn't you?"

"That is what made them; but I will begin at the beginning of the story."

"There was once a time when this part of the

world was colder than it is now. No one knows just why this was so, but there are many theories about it. I will not stop to tell them now. We will just accept it as a fact that it was cold and a great deal of snow fell."

"Then it didn't all melt in summer," said Frank.

"No. The summer heat melted it just a little, but only enough so that it might freeze again and change from snowflakes to little grains of ice. There was an immense amount of snow, more in some parts of the country than in others. Storm after storm swept over the country and the snow piled up higher and higher. This went on for thousands of years."

"What a pile of snow that must have been!" exclaimed Donald.

"A pile of ice, you mean," said Frank.

"If this snow had fallen upon the tops of mountains, as the snow does in the Alps, you know what would have happened to it."

"It would have moved down the ravines in glaciers," said Frank.

"But this snow fell upon a great extent of country, where there were plains as well as mountains. It covered the plains, the valleys, and the mountains all alike. It was a great ice-cap. Can you think what it would do?"

"Of course the great mass of snow on top would crush the snow below," said Frank, "just as it does in the mountains."

"Then what?"

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"Well, if there were nothing to hold it in on the sides, I think it would spread out."

"What would make it spread?"

"The weight on top. The mass above would crush the ice below. Then it would move out and freeze again."

"If I should put a great pile of tar on this board," picking up a piece of board that had been dropped there by the river, "what would it do?"

"It would spread all over the board and run off the sides."

"If I put the tar on the floor of a great hall, what would happen?"

"It would spread out over the floor on all sides."

"Then if I should put a great deal more tar on top of that?"

"It would spread out more."

"And if I should keep on putting tar on top——"

"It would spread all over the hall. The more tar you put on the more it would spread out."

"In some such way this great ice-cap moved. Think, if you can, of ice thousands of feet thick."

"It would be as high as a high mountain," said Donald.

"And about as heavy, I think," said Frank; "and it would keep on spreading until the whole country was covered."

Uncle Robert took his pencil and drew a rough outline of North America.

"Here," he said, pointing with his pencil, "is the country where the ice-cap was."

"That is Labrador," said Frank.

"Yes, and one ice-sheet is supposed to have begun there, and another one here between Hudson Bay and the Rocky Mountains."

"Were there any lakes before the great glacier came?"

"There were probably some lakes, but not so many as there are now. Some geologists think that our Great Lakes—Michigan, Superior, and the rest—were here before the glacier. It is thought, too, that before the time of the glacier there was a milder climate than we have now, and that the landscape was covered with trees and other plants."

"I don't see how they can tell that," said Frank.

"It is told by the remains, which are found far up north, of plants that now grow only in the warm southern climate."

"Isn't it strange," said Frank, "to think of all this country buried under thousands of feet of ice that moved out on all sides?"

"But if it ran up against a mountain it would have to stop," said Donald.

"Yes, at first it would stop, but the ice would keep piling up, filling all the passes, until it pressed its way round the sides of the mountain. This would form an ice tongue or lobe."

Uncle Robert showed with his pencil the form of an ice-lobe.

"But wouldn't it flow around the mountain on both sides as the glaciers do?" asked Frank.

"Yes, it might do so. Then there would be two



lobes which would unite below the mountain. And all the time the ice would be growing thicker and thicker until it reached to the very top of the mountain."

"Then it would go right over the top," said Donald. "Just think of solid ice thick enough to cover a great mountain!"

"And all the time slowly moving over it," said Uncle Robert.

"And grinding off the top!" cried Frank. "That is how the Rib was made. I am sure of it now."

"As the ice-cap crept over the country it filled all the hollows and swept away all the trees. When it came to a river-valley what do you think it did?"

"It froze the river and filled the valley with ice," said Donald.

"If the mountains were covered and all the valleys filled," said Frank, "it must have looked like a great level plain."

"So these two great ice-caps spread north and south, especially south, filling up the hollows and the river-valleys, going through the mountain passes, working along the sides of the mountains, and flowing over their tops. Then the two joined together and made one. It moved all over British America except in the Rocky Mountains, all over New England, and far out into the Atlantic Ocean. It spread down to here"—Uncle Robert drew a line on his sketch of North America—"down to the Ohio and the Missouri Rivers, and in one place across the Missouri River."

"Then it spread all over this part of the country," said Donald.



The United States in the Glacial period. The white tint shows the ice-sheet at the time of the last great advance. The extent of the ice at an earlier date is shown by a darker tint.

"Yes, all this country around us was covered by it, with the exception of one locality, which we shall see before we are through with our journey."

"It must have taken a long time to do it."

"No one knows how long. Now there was one great enemy that fought this immense mass of moving ice."

"What was that?" asked Frank.

"That was the sun," said Uncle Robert. "As this great glacier moved toward the south the sun melted its edge and drove it back. Instead of snow, heavy rain fell and rivers flowed on top of the ice and cut deep valleys into it. But the winter came again and the valleys made by the rivers were filled with fresh snow. Then the edge of the ice-sheet pushed out farther south again. So it went on, year after year; or, perhaps there was a long period of warm years, when it melted far back. Then it became cold again for another period of years, when it spread out again. So the edge of this great ice-sheet, reaching into the Atlantic Ocean on the east and running out upon the great plain, moved forward and backward more times than any one knows. At last the climate became warmer and the ice-sheet slowly drew backward. Back, back it went, uncovering the land from the Ohio River to the region where the Great Lakes now are, back to the Laurentian Mountains, and farther still until at last nothing was left of the great ice-sheet. The sun had won the battle."

"That is a wonderful story," said Frank. "It seems as if it could not be true."



"But how was it ever found out?" asked Donald.

"By the tremendous work that the ice-sheet left behind it."

"I see," said Frank. "You told us about the work of the mountain glaciers, but this great glacier must have done a million times as much work."

"And so it did," said Uncle Robert. "When it went through the mountain passes, or the low places in mountain ridges, it cut down deep into the earth, and the ice was filled with sand, gravel, and boulders. We can imagine the snowslides and the landslides in such places, as they came down upon the ice. The mountains were very high and probably towered far up into the sky with sharp peaks and pinnacles. The great ice-cap came along and slowly rolled up over these mountains, moving over their highest peaks with its tremendous weight. The mountain tops were ground off and borne away in the ice."

"I should think that would have filled even such a great glacier full of rocks and earth," said Frank.

"It must have done so. By and by we shall see what an immense amount of rock was carried by the glacier. It wore down the Laurentian Mountains into mere bones of what they once were. So that now they are scarcely more than good-sized hills."

"Now you know how the marks that you have seen in the rock were made. These striæ or glacial scratches are to be found in most sections of northern North America. You can think of the stones in the bottom of the glacier as scratching and digging into the solid rock as the glacier moved steadily forward.

It is easy to tell the direction in which the glacier moved by the direction in which the scratches run. In New England the glacier moved from northwest to southeast, and the Indians, who of course knew nothing about glaciers, used to tell the directions of points of the compass by the glacial marks.



Tuolumne Monument, a peak of the Sierra Nevada, worn smooth by an overriding glacier.

"The glacier changed the whole surface over which it passed, planing down, smoothing, and digging into the earth. The ice was loaded in this way with a vast amount of gravel and sand and great rocks that were smoothed down into boulders. Every step the glacier took, every mile it moved, the rock was ground up more and more."



"By and by, as I have told you, the sun began to win the battle. The cold fought against the sun through long ages, but as the sun gained the advantage, the glacier was driven back toward the north."

"Then there must have been moraines," said Frank.

"There were immense moraines. Where the glacier melted all around its southern edge it dropped the earth it had carried. These moraines lie all over the country from the Ohio River north. There were few lateral moraines. Can you tell me why?"

"Because it was all one great ice-sheet, without any sides. The lateral moraines are formed in deep valleys in the mountains."

"That is right," said Uncle Robert. "There are lateral moraines only in such places. With this great ice-cap the terminal moraine was the great thing. One of the greatest terminal moraines in the world extends from Minnesota round to New York, and forms the right slope of the St. Lawrence basin, over which the divide runs. They have recently cut through it at Chicago, by the great drainage canal, turning the waters of Lake Michigan, into the basin of the Mississippi, where it is said they once flowed. Sometimes the ice-sheet melted very gradually, and as it melted its load sank down to the earth and formed comparatively level ground. That is called a ground moraine or till."

"Oh, I see now how the bank was made next to Mrs. Lilly's farm."

"Yes, that is a ground moraine. There is little

doubt of it," said Uncle Robert. "Some ground moraines consist, as that does, of gravel and boulders. Others are nothing but sand, and many ground



A bank of till, Bangor, Pa.

moraines are made of boulder clay. This clay is the fine rock flour of glacial grinding. When we go to Chicago and examine the shores of Lake Michigan, we shall find one vast ground moraine of boulder clay extending around the lake, or what was once the shore of the lake.

"I have told you that at all times the southern edge of the great ice-sheet dropped its load of stones and gravel and sand upon the ground. When it became colder, the ice-sheet, as it pushed its way farther south, carried this great mass with it, sometimes smoothing it out, forming something like a ground moraine; sometimes heaping it up, forming an uneven hilly region."

"What a load of rock and earth the glacier must have carried to make such high hills!" said Frank.

"Yes; and it not only made these hills, but the old river-valleys were filled by the material which the glacier dropped as it retreated before the sun."

"Where did the rivers run then?"

"They had to cut new channels, as this river is doing now. Some of them chose the old valleys. Others made new valleys as well as new channels."

"Did the glacier go over our farm?" asked Donald.

"Yes, you can find glacial marks in many places upon your farm."

"Oh, I shall look the first thing when we get home."

"That is what I want you to do. I tell you these things so that you may look at the things around you and be able to read the story of how this wonderful earth is made."

"When the ice melted there must have been a great deal of water," said Frank.

"Yes, there were doubtless great floods, which soon collected into mighty rivers. They began at once to work as rivers do. And under the glaciers also there were streams, and they did much toward changing the land. What would these streams do?"

"They might make great arches under the ice," said Donald, "like those you told us about in mountain glaciers."

"They would bring down the sand and stones," said Frank.



"When they came to a downward slope in the land beneath the glacier, what would they do?"

"Why, they would rush along and take a great load of rock with them," said Donald.

"But when they came to level land——"

"They would flow slowly," said Frank, "and then they would drop their loads."

"Yes. In that respect they must have acted very much as other rivers do."

"But they couldn't have spread out and made flood plains," said Frank, "because the ice on the sides of the arch held them in."

"So how would the earth that was dropped by these streams look after the ice was gone?"

The boys hesitated.

"It seems to me," said Frank, slowly, "that it would be in long ridges the shape of the river-bed."

"That is right; and in many places in this country these low, long ridges of sand and gravel are to be found. They are called eskers. There is another way in which these rivers behaved differently from others. Often they must have flowed up-hill."

"How funny!" said Donald. "Think of a river flowing up-hill!"

"The place through which they flowed was like a tunnel under the ice," explained Uncle Robert. "If this led over a hill, of course the water was forced up much as it is in flowing through a pipe."

"But wouldn't it wear the ice away?"

"Oh, yes, the ice would constantly melt, and that

would add more water to the streams, and more rocks and soil as well."

"What did the streams do when they came to the edge of the ice?"

"There they met the terminal moraines. Sometimes these moraines choked them up, but often they cut channels through them and carried their material



An esker, near Enfield, Me.

far down below the edge of the ice. Often they dropped their own material in mounds and hillocks."

"Were all the hills around here made in that way?" asked Donald.

"I think the glacier made most of the hills we have seen to-day," said Uncle Robert, "but a glacier leaves in its track many different kinds of hills. You remember that I called the long ridge deposited



by the stream under the glacier an esker. Then we find low rounded hills of clay which are named drumlins. Other hills of sand and gravel are called kames. These are all made of material deposited by the glacier in different ways. How do you think the basins among these rolling hills will look?"

"If they are very low they might fill with water," said Frank.



Kames, near North Acton, Me.

"And be lakes," added Donald.

"Yes, there are many such lakes. Then as the ice disappeared it often left moraines in the ends of valleys. This made hollows back of the moraines which filled with water. Do you remember about the ice-lobes? They had lateral moraines. As the ice-lobe melted and dropped a terminal moraine, it joined the ends of the lateral moraines, and so formed hollows."

"Then there would be a lake there, too," said Frank.

"Yes, there are thousands of lakes in Wisconsin, Minnesota, Michigan, and New York, which fill hollows made in this way. But what would become of the deep hollows in the rock that were gouged out by the glacier?"

"They would fill with water, too," said Donald, "and make more lakes."

"Yes, thousands of lakes are held in these hollows in the rock."

"Well," said Frank, "this great glacier just made the country all over new."

"It certainly changed it very much. A country made by the action of glaciers is not like any other."

"I'd like to know how to tell, wherever I go, whether a glacier has been there or not," said Frank.

"Perhaps you can. Let us see. What about the mountains, if there were any?"

"They would be rounded and smoothed off at the top," said Frank.

"Yes, where the rock is rounded like the backs of some huge animals you may be sure a glacier did it. Then where there are rolling hills and long ridges made up of gravel, sand, and boulders, or clay and boulders, or sand and boulders, or sand alone, what would you say?"

"I think they would be moraines, but I am afraid I couldn't tell whether they were lateral or terminal moraines, or kames or eskers."



A drumlin, Groton, Mass.

"That can be determined only by their position and the way in which the soil is laid down. You may be sure if the materials are all mixed together that they were made by ice alone. But if they are stratified and the stones are more rounded, you may be equally certain that water has had something to do with it. Often those who study these subjects a great deal can not be sure as to the name that best suits them. Then there is another difficulty."

"What is that?"

"How to know the difference between river drift and glacial drift. What do you suppose would be the difference?"

"River drift is

ground up fine," said Donald, "and the pebbles are small and smooth."

"If you were in a country where the glaciers had never been, how could you tell it?"

"I don't know exactly," said Frank. "There wouldn't be any glacial drift."

"And the pebbles would be small and round," said Donald. "There wouldn't be many rough, sharp stones."

"The rivers would be older, wouldn't they?" asked Frank.

"Yes ; and what marks an old river?"

"I think you said deep valleys for one thing. Oh, yes, and wide flood plains."

"And wide terraces."

"There are many lakes where glaciers have been," said Donald. "Are all lakes made by glaciers?"

"Oh, no. There are lakes made by the damming up of rivers and many other causes. But where there are many irregular hollows with no regular system of drainage, you may say they are of glacial origin."

"I believe I could tell now," said Frank. "Let me try. First, I would look at the hills. If they were of rock and rounded I should say a glacier ground them off. If they were rolling hills and ridges of sand and clay and gravel, I should say they were drumlins or some kind of moraine. If the land was smooth and all made of clay and gravel, it would be a ground moraine or till."

"And what about the boulders, Frank?"

"If I found a great many boulders of a great



many different kinds of rock, I should say that only a glacier could have brought them, and that they came from many different places."

"But if a glacier carries a boulder very far, it is all ground into pebbles," said Donald.



Lake basin hollowed from the rock by a glacier, Rocky Mountains

"Yes, it may be if it is under the ice. But what if it traveled a long way on top of it?"

"Why, then it would not be ground so small."

"But if you found a great mass of large boulders, as you might in New England, for example, what would you infer?"

"I should say the places from which they came were not very far off."

"Then my pebbles that I found in the gully on Mrs. Lilly's farm came from hundreds of different places," said Donald.

"How far do you think a glacier could carry a large boulder, Uncle Robert?" asked Frank.

"I saw some boulders on your farm that I am



sure were brought hundreds of miles," was the reply.

"Please show them to us when we get home," said Donald.

"And tell us about the place from which they came," said Frank.

## CHAPTER XI

### DOWN THE RIVER TO MOSINEE

AGAIN they were in the boat rowing down the broad river.

"How swift the current is!" said Donald. "Stop rowing, Frank, and let the river do the work."

They floated a little way, Uncle Robert holding the boat in the current with the rudder.

"Let's go to the other side," said Frank, taking up his oars again. "I want to see how it looks over there. We always keep in the current, and so we see only the steep banks that are wearing away."

"It will be hard rowing over there," said Donald.

"No matter. We can do it."

Uncle Robert turned the boat slowly to the right, and they rowed diagonally across the river. As soon as they left the current they found the water shallow.

"What a wonderful thing a river is!" said Uncle Robert.

"It grows more interesting every day," said Frank. "The more I know about it, the more I like to study it."

"We never thought our river was very wonderful," said Donald.

"That is because we didn't know much about it," said Frank. "Since we have been here, Uncle Robert, I have been wondering if our river is as interesting as this one. I believe it is; only we never studied it."

"When we get home we will study it a little and see what makes the difference, if there is any."

As they approached the shore they saw bits of land standing out of the water.

"See the little islands," said Donald.

"The river made them, that is certain," said Frank. "See, they are all sand and gravel."

"I want you to notice the shape of these islands," said Uncle Robert. "I think we would better call them sand-bars."

"The water moves slowly," said Frank. "That is why it dropped all this sand and gravel here."

"The river must be lower now than when these bars were made," said Donald.

"What makes you think so?" asked Uncle Robert.

"Why, don't you see the marks of the water on top of them?" said Donald, pushing the boat close to a bar so they could see better.

"Those are ripple-marks," said Uncle Robert. "Who can draw a profile of one of these islands?"

"Frank can," said Donald; "I'll hold the boat still."

Frank took his pencil and drew one of the bars. The slope up the river was long and very gradual.



A sand-bar

(Fig. 7.) The downward slope was steep and abrupt.

"Can you see why they should slope in this way?" asked Uncle Robert.

"Let me think," said Frank, looking from his sketch to the sand-bars in the river. "The water is loaded with earth, and when it slows up, it drops it."

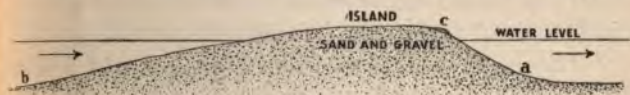


Fig. 7.

"But why does it drop it in these bars?" asked Donald. "Why isn't it spread out smoothly over the bed of the river?"

"There may be stones here to hold it," said Uncle Robert, "or, as is often the case, the waves may have broken here. We will study waves and their motion some time when we have the opportunity. Now, Frank, about the slope."

"Well, I think the water was strong enough to carry the sand and gravel up to *c*. Then its strength was used up and it stopped working. This let the sand go, and it just dropped down to *a*. There wasn't anything to carry it out to make a long slope."

"I think you understand it," said Uncle Robert. "How long will these sand-bars stay here?"

"I should think the first flood would carry them away," said Donald.



"That is possible, but if there should be no flood another thing is possible."

"What is that?"

"If grass and bushes should begin to grow here, what would happen?"

"They would keep the earth from washing away," said Frank.

"They would make more earth stop here, too," said Donald, "and so the bars would grow bigger."

"Then they would be regular islands," said Frank. "They might even grow so big as to unite and make one big island."

"A great many islands are made in this way. We shall see them all the way down the river. When a river has a heavier load than it can carry, it drops part of it. This chokes the river with sand-bars, which often grow into islands. If these bars should be formed across the bed of the river, what would happen?"

"They couldn't if the current was swift," said Frank.

"But if the current was slow——"

"Then it would dam up the river," said Donald.

"What would the water do then?"

"It would spread out and make a lake," said Frank.

"Many lakes are formed in this way, especially where a swiftly flowing tributary carrying a great deal of material flows into a river with slow current."

They got out of the boat to examine the sand-bars.

"They ought to be called pebble-bars," said Don-

ald, "for there are more pebbles than sand in them."

"There must have been lots of sand made from these pebbles," said Frank. "Just see how round and smooth they are."

"And how many different kinds there are, too," said Donald, picking up one after another.

"See the water down there," said Frank, pointing a little farther down-stream. "It is all in ripples, as if the wind were blowing it."

"Let us go on," said Uncle Robert.

The boat glided down to the ripples. There it stuck fast upon the sand.

"How shallow the water is here!" said Donald. "Come on; we must get out and wade."

"The sand is hard," said Frank, as they stepped into the shallow water.

"There are no quicksands," said Uncle Robert. "Always be careful about quicksands. But what makes the ripple-marks? That is the question."

"The water is very shallow," said Frank. "When shallow water flows over the ground, there are always ripples."

"Why?"

"Maybe the bed is uneven," ventured Donald.

"It seems as if the water strikes the ground," said Frank, "and that sends it up. Then it strikes again and again, and that makes it ripple. See, on this bar there are ripple-marks left in the sand."

"Look at them closely," said Uncle Robert.

"Why, they are just like tiny sand-bars?" ex-

claimed Frank. "They have a long slope on the side where the water strikes them, and a short slope on the other side."

"Why are there no ripples in deep water?" asked Uncle Robert.

"There are when the wind blows," said Donald.

"But when the wind does not blow?"

"Does deep water strike against the river-bed as it does here where it is shallow?"

"What do you think?"

"I don't know; but if it does, the reason there are no ripples is because there is so much water above that the water which strikes the ground can't bound back. The heavy water above may hold it down."

"There are many curious things about the way water flows. One thing is certain: it rarely, if ever, flows straight. You can see by these ripples that it has a sort of rotary motion, like a wheel or ball."

They drew the boat over the shallow place and then rowed on. Before them was a little island. Frank dropped his oars to take up the glass.

"A creek flows into the river right there," he said.

He was right. The creek came rippling down between the banks which were covered with trees and bushes. Its water flowed swiftly into the main stream. When it came to the island it divided and ran on each side of it.

"This is a tributary," said Donald, "but it doesn't count for much in this big river."



"Why should there be an island right there?" asked Frank.

"Let us go and examine it," said Uncle Robert.

So they drew their boat up and tied it to a bush. The island was covered with trees and bushes, and as they dug into the soil, they found it to be sand and gravel. They walked around the island and examined its shores.

"Do you think this is river drift?" asked Uncle Robert.

"It looks like it."

"How do you think it came here?"

Frank looked at the creek pouring its small flood into the broad river.

"The creek made it," he declared. "See this little beach? I believe the creek is making this one here all the time. There is no beach on the river side."

"What would you call this bit of land built at the mouth of a stream?"

"Is it a delta?"

"I think so."

"But I thought deltas were only in the mouths of great rivers that flow into the sea or into big lakes."

"Don't you remember the delta we found at the mouth of our creek?" asked Donald.

"Oh, that was only a little bit of a thing that the next spring flood will wash away. This is an island. It isn't going to wash away. These trees will hold it."

"If the creek came in at the opposite side of the river, would there be a delta here?"

"I think not," said Frank. "The current would take away all the earth as fast as the creek brought it down."

"Why is the delta here?" asked Donald.

"Because when the creek with its load rushes into the river, it meets quiet water. This checks its flow, and the sand and gravel are dropped. If the current were over here it would carry it away. It is just so in the ocean."

"But there are no currents in the ocean."

"Yes. There are great currents in the ocean that flow very rapidly. Sometimes these currents flow close to the mouth of a river. Then they carry away all that the river brings down. There is no delta at the mouth of the Amazon."

"There is in the Mississippi," said Frank. "I studied about that at school."

"Is this island growing any?"

"I think it is," said Donald. "This beach is growing."

"And when the spring floods come," said Frank, "the water covers it all over and leaves loads of drift. See there."

Frank pointed back among the bushes where sticks and straw and earth had been washed by a flood.

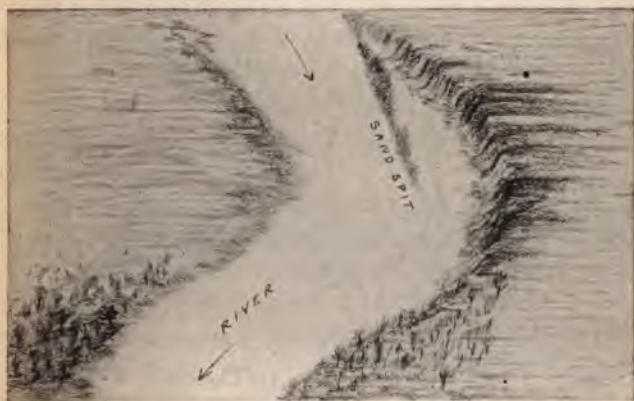
"What will happen if the current swings to this side?" asked Uncle Robert.

"It will take this island away, trees and all."



They crossed to the bank of the river and walked a little way along the creek. On the right was a high bank of glacial drift. Between the bank and the flowing creek was a little flood plain. The eager boys saw everything.

"If this creek should make a bar across its mouth so high the water couldn't flow over it," said Frank, "it would make a lake here."



The sand-bar.

"But if the water cut a channel through the bar," said Donald, "the lake would be drained."

"That often happens," said Uncle Robert. "But if we stay here all day we won't reach Mosinee to-night, as we planned."

So they went on down the river, noticing the banks as they went. Sometimes they followed the concave side with the current. At others they rowed through the shallow water along the convex

curve. At one place a deep concave curve was being cut off by a great sand-bar. Within the bar they could see where the current had once worked. Now the water was still, for the current was flowing on the opposite side of the river.

"What will form here, if the bar builds all the way across this curve?" asked Uncle Robert.

"It will make a straight bank to the river," said Donald.

"And leave a pond back of the bar," said Frank. "I can show you on my paper how it will be."

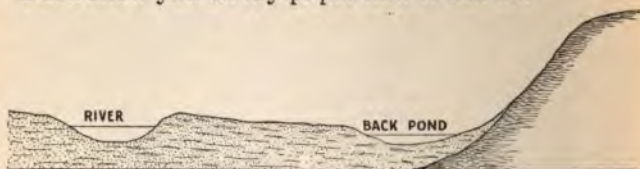


Fig. 8.

He laid down his oars and took up his pencil. (Fig. 8.)

"What makes the river flow swiftly in some places and slowly in others?" asked Donald.

"What makes it flow at all?" asked Uncle Robert.

"The slope of its bed," said Frank.

"Oh, I see," said Donald. "In some places the slope is steep; there it flows swiftly. But when it doesn't slope so much it flows slowly."

"Suppose the land sloped up the river and not down."

"It couldn't do that," said Donald.

"Why not?"

"The water would stop flowing. There wouldn't be any river."

"What would the water do?"

"It would spread out and make a lake," said Frank.

"Well," said Donald, "it would flow on after a time."

"When?"

"When it was deep enough in the lake to flow over the high place in the land."

"I think," said Frank, "that all the earth brought down by the river would fill the lake. Then it would be level land and the river could flow on over it."

"Or when it spread out into a lake," said Donald, "it might find some low place in the rim and cut a channel around the high place in the land. That is what I think it would do."

"What would the water in the channel do?"

"Cut it deeper until the lake would be all drained. It is easy to see that," declared Donald.

"I think the filling of the lake would do just as much toward draining it as the cutting of a new channel," said Frank.

"How so?" asked Uncle Robert.

"When the water reached the lake it would stop flowing; at least, it would flow very slowly. Then of course it would drop all the material it carried. Now when it began to cut a new channel it couldn't work very fast."

"Why not?" asked Donald.

"Don't you remember, Uncle Robert told us that it isn't the water that cuts, but the sand and stones in the water?"

"Well, what of that?"

"Then all the sand and stones would sink to the bottom of the lake. Only the very top of the water would flow to the outlet, and that would be clear, pure water without any sand or stones in it. You know if you fill a pan of milk so full that it runs over, it is the cream that runs off first."

Uncle Robert smiled on the lively argument. He was glad to see how well the boys took hold of the problems to work them out.

"Who is right, Uncle Robert?" asked Donald at last.

"You are both right," he replied. "It is true that the water flowing out of the lake is usually pure, and therefore cuts very little. Still, it does cut a little. So the cutting of the channel and the filling of the bed together gradually drain the lake. We may not find any such places on this river, but they are common on other rivers."

In order to hasten on they dropped into the current. Donald steered while Uncle Robert and Frank rowed. The boat sped along under their strong, even strokes. Donald took the glass and looked to see what they were coming to.

"See that great curve!" he shouted, pointing down the river. A beautiful curve with a bank about thirty feet high lay just before them. The water swept close to the bank, along which were little piles



of driftwood that had been stopped there in their downward journey.

"Let's land here," said Donald. "I know it is time for lunch."

"How shall we land in this swift current?" asked Frank.

"We shall find an eddy soon," said Uncle Robert.

Sure enough. Just beyond the middle of the curve the water was flowing up-stream instead of down. Pieces of wood that were floating swiftly with the current stopped when they came near the shore at this place and then turned round and drifted up the river.

"Isn't that a funny thing to happen when the current is so swift?" said Donald as they drew the boat into the eddy.

"Yes, it is strange," said Uncle Robert. "But what turns the water back?"

Frank was looking at it closely.

"The current comes along this bank," he said, "and if the curve were wider it would go farther. But right here the curve begins to bend out again, so the current strikes the bank. That stops the water so suddenly that some of it is forced back up the river a little way."

"There is a place just like this on the Davis's side of our river," said Donald. "It is where they keep their boat."

"That's so," said Frank.

"It is an eddy," said Uncle Robert.

They drew up the boat and climbed the bank.



Their feet sank deep into the loose gravel and the pebbles rolled down to the narrow beach. On the top of the bank the land was quite level. Away to the north lay their friend the Rib. They could see its outline distinctly against the clear sky. On top of the bank was a long line of logs waiting for the flood time, when they were to be rolled into the river and floated down to the mills at Mosinee. Back of the logs was a dense growth of blackberry-bushes. The ripe fruit hung in rich clusters. Donald forgot about lunch. He made one plunge in among the bushes. Uncle Robert and Frank joined him. All round they heard the twittering of birds.

"No danger of the birds starving here," said Uncle Robert. "What flocks of them there seem to be!"

The boys were too busy to notice the birds. They were simply eating their way into the blackberry-patch. Uncle Robert took time to look around him.

"Boys," he said, "did you ever see so many flowers? What do you think Susie would do if she were here?"

"Wouldn't she be happy!" said Frank. "Just see those wild roses, Uncle Robert."

"And the bluebells. I never saw anything more beautiful than they are."

"Let's go and get lunch now, Don," said Frank. "We must leave a few berries for the birds."

When lunch was over Donald commenced to collect pebbles. Uncle Robert sat on one of the logs and looked up and down the river, and over the coun-

try that lay spread out before him. Frank took his camera and went away to find the best view of the bend of the river.

"This is a beautiful curve," he said, as he returned to where Uncle Robert sat, "and it was all made by the river."

"But the river didn't make this bank," said Donald, who was sorting over the stones he had collected.

"This bank was made by the great ice-cap, of course," said Frank. "I wonder if the top of the Rib that the glacier ground off is mixed into the bank."

"Some of it may be here," said Uncle Robert, "but not all, I think. The ice usually carries its load much farther than that."

"Oh, wouldn't it be strange," exclaimed Donald, "if some of the boulders on our farm came from that very Rib? I wish we could know."

"There are not many large boulders here," said Frank.

"When the current swings to the other side of the river what will happen here?"

"This place will fill up and make a beach, and after a while it will be a flood plain."

"Let's go now," said Donald.

The sun was shining hot upon the water as they rowed swiftly along. They kept in the current, crossing the river back and forth as the current crossed. As they went they talked of many things. Uncle Robert told them of other places which he had seen. They told him of their life on the farm. Sometimes

they rowed on in silence watching the changing scene as the boat fairly danced along.

"How far to the falls of Mosinee?" called Uncle Robert as they passed a man on shore.

"About two miles," he replied. "Be careful or you'll be drawn in. Stop at the boom above the falls."

They saw him shake his head as they rowed swiftly on.

"He thinks we don't know enough to stop," laughed Donald.

The sun crept behind the western bank of the river. The water looked dark and troubled in the shadows. By and by it flowed more slowly and the rowing was harder. The river became much wider.

"Is this a lake?" asked Donald.

"No, I think not," said Uncle Robert.

"The river is just growing," said Frank.

"What makes it grow?"

"All the tributaries that bring more water."

"Why does the water flow so slowly?"

"Perhaps the land slopes up-stream," said Frank.

"It's a dam," said Donald. "You know how our river is above the dam."

"Donald is right," said Uncle Robert. "There is a dam just below here."

In the distance they saw some old mills. Then the river turned abruptly to the right.

"Look at the rock on the shore," said Frank. "That is gneiss, isn't it? How did it come here?"

"It is like the rock at Wausau, where the dam is," said Donald.



"What do you suppose is under all this glacial moraine through which the river has cut?" asked Uncle Robert.

"Solid rock, of course," said Frank.

"Yes, and probably rock just like this. Here the rock is higher, so the moraine does not cover it, and the igneous rock crops out."

Soon they came to some great logs, fastened together across the river.

"We can't get through here," said Donald, resting on his oars.

"This is the boom where the man said we were to stop," said Frank.

"I think we can go through this one," said Uncle Robert; "I know a way."

He steered the boat to one end of the boom. Then he stepped out upon the logs where two of them crossed. He pried them apart, leaving a gateway for the boat to pass through. They floated on into the pond, partly filled with logs. Then they came to another boom where Uncle Robert again opened the boom switch.

"These ponds are storehouses for the logs," he explained, "and the booms keep the logs from going down the river."

"At Wausau the logs are kept in the ponds until they are needed at the mills," said Donald.

They could hear the water roaring at the falls.

"We can't go any farther," said Frank.

They rowed to shore and tied the boat. Then they walked on to see the falls. A dam had been



built across a narrow place in the river and the water poured over it. Below the falls the river was only a few rods wide, and it dashed and foamed in its narrow channel.

"I shouldn't dare to row a boat through there," said Donald, as they stood on the bridge below the falls.

"I should think not, sonny," said a man who was passing by. "That's no place for a boat, though some have been foolish enough to try it."

"Did they ever get through alive?" asked Uncle Robert.

"Well, in high water some of the raftsmen make it, but hundreds of lives have been lost there. Last year some young men tried it, but their boat tipped over in no time. Then boat, baggage, guns, fishing-tackle, everything, went away down the river."

"What became of the young men?" asked Frank.

"Oh, they were fished out with considerable difficulty, but they had had enough of the rapids. Strangers here, sir?" to Uncle Robert. "Come over to the mill yonder before you leave, if these young fellows would like to see what is done with all the logs."

Then he went on his way and Uncle Robert and the boys went back to the boat. They found a man with a wagon to take the boat around the falls, and by dark they were camping on a little flood plain, bordered by a thick forest of elm-trees.

## CHAPTER XII

### RAPIDS AND TRIBUTARIES

THE next morning they were up early. When breakfast was over Frank took his camera and they walked back to see the rapids and the dam again.

"What makes the river so narrow here when it is wide above the dam?" asked Donald.

"I don't see how it is possible for all the water between here and Wausau to flow through this narrow place," said Frank.

"Where else could it flow?" asked Uncle Robert.

"It must come this way," said Frank, "but I can't see why the channel should be so narrow here."

"What kind of earth are the banks above made of?" asked Uncle Robert.

"Sand and gravel," said Donald.

"Glacial drift," said Frank.

"And what kind of banks are here?"

"Hard rock," said Frank. "It looks like the very hardest kind of rock."

"See those great pieces with sharp corners down there" said Donald. "They are not boulders, and

they were not brought here from anywhere else. They are just like the rock that is cropping out along the river above the rapids."

"They are granite or gneiss," said Frank.

"But see that black band in the white rock," said Donald. "Why should it be that way?"

"That is called a dike," said Uncle Robert, "and the story of how it was made is a very wonderful one. This white rock was made first. Then some great force within the earth cracked it open, and the black rock in a molten state came up to fill the crack. Later on we shall learn more about dikes. Where do you think the river would have the easier work in cutting its channel, Donald, here or back where we found the wide curve?"

"Any place between here and Wausau would be easier than this," said Donald. "It's harder to cut rock than it is to wash away sand and gravel."

"So the river has found out," said Uncle Robert. "This granite or gneiss stood in the way and the river had to cut its way through. It has worked hard, but in all the time it has been flowing it has cut only this narrow channel."

"Will it ever be wider?" asked Frank.

"Some day it may be wider."

"The bed of the river slopes a great deal more here than it does above."

"That is why it flows so fast," said Donald.

"This slope is increasing all the time," said Uncle Robert.

"How?" asked Frank.

"Can you see the kind of rock which lies just a little farther down the river?"

"It looks like glacial drift," said Frank, "but of course the bed of the river may be different."

"Whatever it is," said Uncle Robert, "it is much softer than this igneous rock. Now what happens when the water rushes over this hard rock upon the softer bed?"

"Why, it just digs into it with all its might," said Donald.

"And that must wear the bed away faster than this hard rock is worn," said Frank.

"You know there is something else to wear it beside the water," suggested Uncle Robert.

"Oh, yes, the rocks that the water carries," said Frank.

"If it takes many like those rough pieces down there, they must dig down pretty deep," said Donald.

"Now can you see how the slope is increasing?" asked Uncle Robert.

"I can," said Frank, "and if this rushing water and the sharp rocks dig away down deep there will be regular falls here some day."

"Will they be as great as Niagara Falls?" asked Donald.

"I can not tell that," replied Uncle Robert. "Perhaps when Niagara has ceased to be a fall, this may be a very great one."

"Will the time ever come when there will be no Niagara Falls?" asked Frank in wonder.

"They tell us that the Falls of Niagara are re-



ceding all the time. The rock over which the Niagara River flows is a hard limestone. You know how limestone is formed."

"It is stratified," said Frank.

"Under this layer of limestone there is one of a soft shale. Now as the water dashes over the falls it wears the shale back under the layer of limestone. Then, piece by piece, the limestone breaks off and falls into the stream below. The strata of limestone and shale dip in such a way that as the falls recede they are becoming lower. Let me have your paper, Frank, and I will show you how it is." (Fig. 9.)

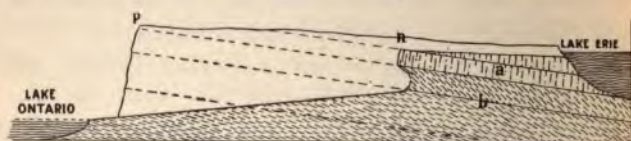


Fig. 9.

Uncle Robert drew carefully, the boys watching closely. When the drawing was finished Donald exclaimed:

"I see how it is. When the falls have cut back to Lake Erie, the river will be all rapids."

"I should think it would drain Lake Erie," said Frank, looking at the drawing.

"And so it will in part, at least," replied Uncle Robert. "But let us come back to our rapids here. Why was the dam built just at the head of the rapids?"

"To hold the logs back," said Donald.

"There is another reason far more important than that," said Uncle Robert. "Do you see the canal over yonder?"

"I see why it is," said Frank. "That canal is like the sluice in our mill. It takes the water out of the river to turn the wheels of those mills."

"It did once," said Uncle Robert, "but now most of the mills are run by steam. The dam was built for that purpose, however. The question is, why was this spot chosen as the place for a dam?"

"The dam at Wausau is built where the hard rock comes out just as it does here," said Frank, thoughtfully..

"Almost all dams for water-power are built in just such places," explained Uncle Robert. "The hard rock narrows the channel, and that with the slope gives the water more power. What would happen if the dam were built where the rock is soft?"

"The swift water would wear away the soft rock, and then the dam would go, too."

They walked over to the mills, where they spent a short time. Then they went back to the tent, broke up camp, and were soon drifting down the river again. Uncle Robert and Frank were pulling at the oars. Donald was steering and at the same time looking through the glass at the curving banks before them. Suddenly he dropped the glass.

"Oh, look! He's gone!"

Uncle Robert and Frank turned about quickly. They saw nothing but the dense growth of bushes and trees along the shore.

"What was it?" they asked together.

"A deer! I know it was a deer. He jumped into the bushes. Oh, I wish we could see him nearer! Let's go ashore and look for him."

"I'll take the gun," said Frank. "It would be great to shoot a deer."

Donald steered the boat to a small sandy beach. There were fresh tracks in the soft sand, but that was the only sign of the deer left.

"Let's follow him," said Donald.

"He's too far away by this time. He came down here to drink," said Uncle Robert.

Frank walked a little way into the woods.

"There must be more than one deer around here," he said, "for there are paths just like cow-paths all through the woods. They must come here every day to drink."

"Once there were a great many deer in this part of the country," said Uncle Robert. "In fact, they roamed freely over North America. But when a country becomes settled, the deer leave. They are shy and defenseless animals."

"It seems a shame to kill them," said Donald. "Oh, but I'm glad I saw that one, if it was for only a second."

They had landed at what seemed to be an inlet or bay. The water was still.

"What makes this place?" asked Frank.

"It's a creek," said Donald.

"But the water isn't flowing into the river," said Frank.



"Let us row up and see if it is a creek," said Uncle Robert.

On their left as they went was a high bank partly covered with trees and bushes.

"Running water cut that," said Frank.

"It certainly looks so," said Uncle Robert.

"It took a long time to do it, too," said Donald.



The creek.

"The water from the main stream didn't cut it," said Frank.

"See, there is a flood plain," said Donald, pointing to his right, "and another high bank beyond."

"This must be a creek," said Frank, looking puzzled; "but why doesn't the water flow? It is as still as a pond."

"Steeply cut banks, a flood plain, and that little island at the mouth surely speak plainly of run-



ning water," said Uncle Robert. "Let us row farther."

They pulled about thirty rods from the mouth, when suddenly Donald discovered that the water was moving.

"What makes it move?" asked Uncle Robert.

"The slope of the bed," said Frank.

"But why doesn't it move between this point and the main river?"

"It must be that there is no slope to its bed," said Donald.

"But it did move once," said Frank, "for it cut those banks and made this flood plain."

"And the island," added Donald.

"When did it stop flowing?" asked Uncle Robert.

"It must have been when there wasn't any more slope to its bed."

Frank took his pencil. (Fig. 10.)



Fig. 10.

"Perhaps the rock in the bed of the creek is softer than in the bed of the river," said Donald.

"What then?" asked Uncle Robert.

"It would wear away faster," said Donald.

"And when it had cut down from the top of this bank until its bed was lower than the bed of the river it stopped flowing," said Frank.

"What makes it flow from *a* to *d* in your figure?" asked Uncle Robert.

"It hasn't worn its bed quite so low there as it has here."

"But the water does flow a little," said Donald, "for the creek goes into the river somehow."

He threw a twig into the still water. It seemed to stand still, but very slowly it moved toward the river.

"The running water above pushes it down," said Frank. "Uncle Robert," he exclaimed suddenly, "if the creek above brings down silt, it must drop it here in this still water. That will fill the bed up, won't it?"

"If it fills it full the creek will stop flowing," said Donald.

"But if the creek should cut a channel through it there would be a delta," said Frank as they rowed back to the little island that lay at the mouth of the creek.

"This is a delta," said Donald. "The creek must have made it when it was working."

"Will all creeks and rivers cut down so low?" asked Frank.

"Yes, that is what they are all working to do. When they have cut down at the mouth as low as the bed of the body of water into which they flow, they gradually work back."

"How far back will this creek cut?" asked Frank.

"What do you think about it?"

"If the water keeps on running it may cut back to its source."

"It will be some time before it does that," said Donald.

"I am glad we discovered this little creek," said Uncle Robert, "for it shows us very plainly what all rivers are working for. When a stream has cut as low as this creek has, it is said to have reached its base-level. In reality the base-level of a river is the level at which it neither cuts nor deposits. If it is higher than the body of water into which it flows, it seeks this level by cutting. If it is below it, it seeks it by depositing."

"Then the base-level of this creek is the level of the river," said Frank.

"What is the base-level of the river?" asked Donald.

"What do you think?"

"It is the level of the Mississippi," said Frank, "and the base-level of the Mississippi is the level of the Gulf of Mexico."

"Will these rivers ever cut down to that level?" asked Donald.

"If nothing happens to interfere they will," answered Uncle Robert.

"What could happen?" asked Frank.

"Sometimes the land over which a river flows rises."

"I wish it would rise here now," said Donald. "I'd like to see it."

"We hardly have time to wait to see the effect of it if it should," said Uncle Robert, smiling.

"What do rivers do when the land rises?" asked Frank.



"If the land rises sufficiently at the mouth of a river the water is turned the other way."

"Then it makes a lake."

"If the land rises at the source of a river, what effect does it have?"

"Why, that would make the slope greater," said Frank.

"And the river would flow faster," interrupted Donald.

"But often the land rises across the course of a river. It rises slowly, and the river keeps on cutting as fast as the land rises."

"That would make very high banks," said Frank.

"Yes. In the Rocky Mountains there are gorges thousands of feet deep that have been cut in this way. Lookout Mountain, in Tennessee, where General Hooker fought a great battle, was cut out by the Tennessee River as the land rose."

"Does the land ever sink?" asked Frank.

"Sometimes."

"What happens then?"

"Look at this creek and see if you can tell."

"If that land along the creek should sink lower than this river, the water of the river would flow into the creek and fill it up."

"That is right. The creek would be drowned."

"How funny!" laughed Donald. "Think of drowning a river!"

"I can think of another way by which this part of the creek may begin to flow again."



"Is it a problem?" asked Frank.

Uncle Robert pointed across the river to the high concave bank. The current was flowing swiftly there, while all around the little island on which they stood the water moved very slowly.

"Some day that current may swing over here," said Frank.

Uncle Robert nodded and smiled.

"Then it will cut a deep channel on this side," continued Frank.

"And wash away this island," added Donald.

"Then the bed of the river will be lower here," said Frank, "and so this creek will flow again."

"Hurrah for you, Frank!" shouted Donald. "I never should have thought of that."

"It's easy enough," said Frank, "if you think a little."

"I thought about the island," said Donald, skipping a stone over the smooth surface of the water.

"What would the creek do when it commenced to flow again?" asked Uncle Robert.

"It would cut down some more," said Frank, "until it reached a new base-level."

They launched the boat once more and pulled down the river. Every mile was full of enjoyment; every bank and curve was examined. The islands, the flood plains, the glacial drift, and the outcropping rocks were subjects of constant interest.

Donald always kept a sharp lookout for the birds. While looking for the deer tracks near the creek he had started a shy olive-backed thrush in the dense

thicket; he had seen a swamp sparrow fly from her nest; and high overhead in an elm-tree, they had heard the midday song of a red-eyed vireo.

As they went on down the river they spied many a blue heron on the low pebbly beaches, but as they drew near the tall, ungainly birds flapped their great wings and flew across the river beyond their sight.

"See that high bank," said Frank, pointing across a flood plain where some tall elm-trees were growing.

"Let us land and take a look at it," said Uncle Robert.

Frank, who was steering, brought the boat to the shore, and swung it round into a little eddy. The flood plain was not so wide as the one on which they had camped at Wausau.

"It slopes toward the high bank," said Frank.

"It isn't a flood plain at all," shouted Donald, who had run ahead. "It's an island. There is water around by the bank."

"Perhaps at high water the river cut through the low place near the bank."

"But the water doesn't flow at all," said Donald.

"Perhaps something has dammed it up below," suggested Frank. "How shall we get across?"

"Wade," said Donald, beginning to roll up his trousers.

"It's too deep," said Frank.

Just then a farmer driving two horses came down a road cut in the side of the bank.

"Want to come over?" he called. "Wait; I'll help you."

He left his horses and shoved an old leaky boat across to them.

"Thank you," said Uncle Robert, as they paddled over at some risk of a bath.

Then they climbed up the bank.

"This is glacial drift," said Frank.

"But the river cut this bank," said Donald. "Let me draw the profile."

"This bank is not so steep as it was when the river left it," said Uncle Robert.

"The earth rolls down, doesn't it?" said Frank.

"And the rains wash it," said Donald.

"Every steep slope is constantly trying to become level," said Uncle Robert.

"I'd like to know why that water doesn't flow," said Frank, pointing to the channel they had crossed. "There is some reason for it. Let us find out what it is."

"Perhaps it has reached its base-level," said Donald.

Frank shook his head.

"I don't believe it is that. It isn't like the creek."

They walked along the edge of the high bank. The surface of the land beyond was level, with low hills in the distance. Suddenly they came to the end of the bank. Another bank from the left joined the one they had been following, forming a kind of promontory. All around the promontory lay the flood plain partly covered with trees.

"Here is a problem," said Donald. "I am sure no one can tell how this sharp, pointed bank was cut."



"Both of these banks were made by a river," declared Frank.

"But I can't see how that big river could have come down here and turned so sharp a corner to cut that bank. Do rivers turn corners like that, Uncle Robert?"

"Not often, I think," said Uncle Robert, smiling.

They went down on the flood plain, where Frank took a picture of the point.

"It is all dry land here," said Uncle Robert.

Donald went to find out what had become of the quiet water they had crossed in the old boat. Soon he came running back.

"It stops up there," he shouted. "It is dammed up. It doesn't go back into the river. This isn't an island."

"What stops it?" asked Uncle Robert.

"The earth stops it, but I don't know how it was done."

"I think these trees and bushes hide the secret," said Uncle Robert; "let's go through them."

Soon they heard the gurgling and splashing of water.

"Another river!" shouted Frank. "See, it is just pouring into the Wisconsin. It hasn't reached its base-level."

"It is a working river, for sure," said Donald, throwing a chip into the stream and watching it float swiftly out to the main river."

"Now for the problem," said Uncle Robert. "How was that sharp point made?"



"By both rivers, I think," said Frank.

"How?"

"Well, the Wisconsin River cut the side of the bank we came to first and this river cut this one. Then both together they made this flood plain."

"That is a good guess," said Uncle Robert; "but can you tell how this work was done?"

"Perhaps," said Frank, slowly, "when the banks were cut, the currents in both of the rivers flowed close to this bank. Then of course all the earth brought down by the little river was carried away by the current of the big one. But after a while the current of the Wisconsin River changed and a flood plain was built along its high bank. Then a flood came that cut the channel close to the bank, making the flood plain an island."

"What became of the material brought down by the tributary then?" asked Uncle Robert.

Frank thought a minute.

"It must have been dropped at the mouth of the tributary," said Frank, "because there wasn't any current on this side to carry it away."

"That would make a delta," said Donald, thinking of the island at the mouth of the creek above Mosinee. "But what I want to know is what dammed that channel up?"

Frank continued, "The current of this tributary swung away from its bank and built a flood plain."

"At the same time that the large river left its bank?" asked Uncle Robert.

"I think it must have been after the Wisconsin

River had made its flood plain and cut that channel."

"What makes you think so?"

"I think the water flowed through the little channel, and so the flood plain was an island. But the current wasn't very strong there; so, as the little river dropped its load, a bar was built right across the mouth of the channel. This stopped it up, and as the river brought down more and more earth, it grew to be a part of the flood plain."

"Very well worked out," said Uncle Robert, much pleased. "Then there are two flood plains here?"

"Yes, the flood plain of the Wisconsin River and the flood plain of this tributary."

"This is a good big river," said Donald. "I wonder if it has a name."

When they got back to the boat Uncle Robert looked at his map and decided that it was the Eau Claire River.

"We sha'n't forget the Eau Claire River, shall we?" said Donald, as they went on their winding way.

## CHAPTER XIII

### SHOULD A RIVER WIND, OR RUN STRAIGHT?

THEIR next camp was in the woods beside a little creek. While Uncle Robert wrote a letter to be posted when they should reach Stevens Point, Frank and Donald took a tramp into the woods.

They looked everywhere for deer tracks, but they found none. The only animals they saw were rabbits bounding away through the bushes at the sound of their footsteps, and squirrels frisking about among the trees. They saw a few of the woodland birds that they had seen along the way, but the sun-loving birds were not as numerous in the dense woods as in the open country.

Early the next morning the boat was loaded again, and once more they were rowing with the current.

"How many bends there are in the river!" said Frank. "The farther down we go the more it curves."

"It takes too much rowing to go just a little way," said Donald. "It would be a great deal easier if the river were straight, like a railroad."

"Then you think, Donald, that it would be better if there were no curves in a river?"

"Oh, I shouldn't like it so well," replied Donald.

"You see more of the country if the river winds about. But if I were in a hurry to go from one place to another, it would be better if the river were straight."

"Was there ever a perfectly straight river?" asked Frank.

"I never heard of one," said Uncle Robert. "All rivers curve more or less. But suppose this river were perfectly straight from its source to its mouth, what would happen?"

"That is a problem," said Frank.

"Yes," said Uncle Robert. "Now try to work it out."

"Well," said Donald, "if it were straight it would be shorter."

"It wouldn't do much work," said Frank.

"What do you mean?"

"It wouldn't cut away banks and make flood plains. There wouldn't be any curves."

"Of course not," said Donald, "if it were straight."

"I think it would run very fast," said Frank.

"Why so?"

"Because there would be nothing to stop it. You see when the current strikes against that bank over there it holds it back a little. That is what makes an eddy. Then it is thrown diagonally across the river, where it strikes against the opposite side. It seems to do so all the way down the river, and of course that makes it go more slowly."

"If the river were straight, where would the current be?"



Frank thought a minute, then he said:

"It would be in the middle of the river."

"And it wouldn't dig into the banks at all," said Donald, "so they wouldn't be worn away."

"It might wear a little if there was a flood," said Frank; "and if the earth were softer in one place than another it would take away more there."

"Then that would make a curve," said Donald.

"Well, we will have to suppose that there is the same kind of earth from its source to its mouth."

"But there couldn't be such a thing," interrupted Donald.

"We are supposing," said Uncle Robert, smiling. "Now if there was nothing to hinder the flow, no banks to strike against——"

"It would go faster and faster from the source to the mouth."

"Wouldn't it just rush along!" exclaimed Donald. "How fast would it go?"

"Oh, faster than the rapids at Mosinee. There wouldn't be any still places in it unless there was a dam."

"It would tear away the dams."

"Would there be any erosion?"

"I never heard of that before. I don't know what it means."

"Erosion means eating or wearing away. Would a straight river erode or wear away the land?"

"Not on the banks."

"Anywhere else?"

"I think there would be a great deal of erosion

on the bed," said Frank, "for the swifter a river flows the more it wears."

"What would become of all the material eroded?"

"It would be carried on and on into the ocean. It wouldn't be dropped along the way, for the river would flow more swiftly all the time, and the more swiftly water flows the heavier load it can carry."

"If it kept cutting deeper and deeper, the banks would be very high," said Donald.

"How far down would it cut?"

"Well, by and by it would cut down to its base-level at the mouth."

"Why at the mouth?"

"It wouldn't have to cut so far there as it would farther back, and it would have more tools to cut with. If it should reach the base-level anywhere else first, the water would stop running."

"What would it do when it reached base-level at its mouth?"

"Then it would work back from the mouth."

"How far?"

Frank looked thoughtfully into the water.

"After a long, long while," he said, "it would dig down so that the whole river-bed would be at base-level."

"That would make very high banks, wouldn't it?" asked Donald.

"Where would the highest banks be?"

"At the source," said Frank, "for that must be the highest land."

"If a river flowed into the sea, and the source was a thousand feet above the sea——"

"Then the banks would be a thousand feet high."

"That would be no kind of a river," said Donald.

"Why not?"

"It would be no use to anybody. We could never take a jolly trip in a boat like this on such a river."

"It wouldn't be of any use for navigation, that's sure," said Frank. "If a dam were built in it the river would tear it away; there would be no such thing as crossing it without a bridge, and it would never make flood plains for farms."

"It would be just a great deep ditch right through the country that would do nobody any good," said Donald.

"So you would rather have a river wind?"

"Oh, yes. That is the only way to have a river."

"This river doesn't wind nearly so much as some rivers do. Did you ever hear the word 'meander,' Frank?"

"I think I have," said Frank, "but I can't remember what it means."

"There is a river in Asia Minor that winds and turns and twists like a snake. It is called the Mæander, and from it we get this word, which means to wind in or out as a river. Generally a river winds most when it makes its way through the softest soil. And the curious thing about a river is that, although no river in the world is straight, or ever will be, all rivers try to straighten themselves."



"Isn't that strange?" said Frank. "What difference could it make to a river whether it were straight or curved?"

"Just see this bend!" said Donald. "If we could go straight across this narrow piece of land it would be ever so much shorter than to row around the bend."

"Let us get out and walk over," said Uncle Robert.

"But what shall we do with the boat?"

"Oh, we'll come back after we see this little peninsula, for that is what this really is."

"It is a piece of land nearly surrounded by water," said Frank, thinking of his geography lessons at school.

"What would you call the narrow neck of land over which we are walking?" asked Uncle Robert.

"It joins the peninsula to the mainland," said Frank, "so it's an isthmus."

"This used to be a flood plain," said Donald, "but if this isthmus keeps on growing narrower it will be an island some day."

"It's sure to be," said Frank. "Don't you see, it is wearing here on this lower curve just as it is on the upper one where we left the boat. Now this will surely be cut off some day, and the river will flow right across here instead of clear around that bend."

"That will make the river a great deal straighter here," said Donald.

"But what will become of the bend?"

The boys looked across the river, then back toward the boat.



"I could tell better if I could draw it on paper," said Frank.

"Very well. We will go back to the boat."

Frank took his paper and drew the deep bend. (Fig. 11.)

"Now," he said, pencil in hand, "the river will cut through this isthmus. Then the current will flow through here instead of around the bend. After a while the ends of the bend will be closed up by the earth deposited by the river."



Fig. 11.

"Then the bend will be a lake!" exclaimed Donald.

"There are many such lakes along the Mississippi River, made in just this way. They are called ox-bow lakes."

"We haven't seen any lakes along this river," said Frank, "but we have learned of a great many ways in which they are made."

"Tell me what they are," said Uncle Robert.

"Well," said Frank, "this ox-bow lake is one, made by a river making a new channel through an isthmus and cutting off a bend. Then there is the lake made by a sand-bar turning across a deep curve. This straightens the river and leaves a lake back of the bar."

"If the mouth of a tributary is choked up, the tributary spreads out and makes a lake," said Donald.

"A dam built across a river forms a lake, too," said Frank.

"But there are more lakes made by glaciers than any other way," said Donald.

"Were the lakes we saw as we came up on the cars made by glaciers, Uncle Robert?" asked Frank.

"Yes, I think they are all glacial lakes."

As they rode around the bend Donald said:

"I wonder how long it will take to make this peninsula into an island."

"If a great flood comes it might be done very quickly," said Uncle Robert. "How many different kinds of islands have we seen on this river, Frank?"

"I can remember two kinds. One is the island at Wausau; that was a flood plain, and at high water a channel was cut next the old bank. Sometimes the earth brought down by a river is piled up into a bar. If it isn't washed away after a while grass and bushes grow on it. Their roots hold the soil and the river keeps bringing down earth and adding it to the up-stream side until a real island is



Meanders of the Mississippi, with cut off lakes.

built like that one," pointing to an island covered with large trees.

"Islands are made by tributaries, too," said Donald.

"Tell us how they do it, Donald," said Uncle Robert.

"The tributary brings down mud and sand and gravel. If the current of the river is on the opposite side, the load is dropped down at the mouth of the tributary. If it filled up the mouth there would be a lake, but it doesn't. The tributary cuts new channels around it, and that makes a delta island."

"Good," said Uncle Robert; "and now we have found a new way to make an island."

"Yes," said Frank; "when a river cuts a new channel through an isthmus and makes an island out of a peninsula."

They were nearing Stevens Point, where there was a great bend. The boys kept an eager lookout for each change of scene. They pointed out all the flood plains, and were quick to guess how the islands were made. They saw log booms ahead of them again.

"We must be near Stevens Point," said Uncle Robert. "I think we'd better land and camp here to-night. There's a stone quarry here that I wish you to see."

They chose a clump of trees in a pleasant spot and headed the boat in that direction.



## CHAPTER XIV

### A VISIT TO THE QUARRY

THE next morning they went to visit the quarry across the river. As they walked through the town Uncle Robert stopped in a drug-store, where he bought a small bottle of hydrochloric acid.

"What is it for, Uncle Robert?" asked Donald. "Is anybody sick?"

"Oh, no," replied Uncle Robert, smiling. "You shall soon see what it is for."

Then they went on over a bridge, from which they could see the dam.

"Is this gneiss or granite?" asked Frank. "I remember you said that the best place to build a dam is where there is hard rock."

"Yes, this is the same kind of rock that we have seen all along the way. There are several dams between Stevens Point and Nekosa, built where the hard rock comes to the surface. But now we shall see the beginning of another kind of rock."

"What is it?" asked Frank.

"It is one kind of sandstone. There is another kind farther down the river."

They went up a little hill, where they found the



quarry. It was deep and wide, for a great deal of stone had been taken out. The stone was a hard gray sandstone, used for building purposes. A few men were at work prying off great slabs.

"It is limestone," said Donald. "See, it is stratified and is almost the color of the limestone at our spring."

"No," said Uncle Robert, "this is not limestone, although there is lime in it. This is sandstone."

"Is it called sandstone because it was made from sand?"

"Yes. It was made from sand."

"Do you mean, Uncle Robert," asked Frank, "that all this hard rock was once fine sand like that we have seen along the river?"

"Probably so."

"How did it ever become so hard?"

"You remember, do you not, about the rocks formed in the ocean from the material brought down by the rivers?"

"Oh, yes; the limestone."

"And the sandstone as well."

"But how could sand be stuck together so as to make this hard rock?" asked Frank.

"The lime in this rock acts as a cement."

"Lime is used in making plaster," said Donald. "But how do you know that there is lime in this sandstone, Uncle Robert?"

"We will see if we can find out," replied Uncle Robert, taking the bottle of hydrochloric acid from his pocket. "This is an acid, and we know that

when an acid comes in contact with lime, what is called a chemical change takes place. I mean by this that some element or part of the acid goes into the lime, and some part of the lime unites with other elements of the acid. In this action new substances are formed, some of which are solid, some liquid, and some gaseous."

"If you pour this acid on the sandstone can we tell if there is lime in it?" asked Frank.

"Yes."

"Let's do it," cried Donald. "Here is a piece just broken out of the quarry."

Uncle Robert poured the acid on it.

"Oh, see it bubble!" cried Donald. "Is it the lime that makes it do so?"

"Yes, and these bubbles are caused by the escape of the gas I told you of."

"Would our limestone at home do the same way?"

"Yes."

"I'm going to try it when we get home. Won't Susie open her eyes to see it!"

"What is this gas that is escaping, Uncle Robert?" asked Frank, who was watching the acid still bubbling on the rock.

"It is called carbon dioxide, and is a combination of two elements called carbon and oxygen. This gas is always present in the air and in all water. When we breathe, carbon dioxide passes off from our lungs; this is true of all animals. The same gas is formed by the decay of vegetable and animal matter, and by burning any substance in the air."

"I should think that after a while the air would be all carbon dioxide," said Frank.

"Yes; but the wonderful thing is that this very carbon dioxide is the particular food of plants. They take it out of the air and the water, and, with the help of the bright sunlight, change the carbon into leaf, branch, and root, and give the oxygen back to the air again for us to breathe. No animal could live without oxygen, so you see how wonderful all living things help each other."

"See," said Frank, "that acid has made a hole in this rock."

"Can you think what would happen if water containing this acid should flow over land where there is lime?"

"It would make carbon dioxide," said Frank, quickly.

"But water doesn't have acid in it, does it?" asked Donald.

"Very often. In fact, rain and almost all waters contain some kinds of acid. You remember what I told you about the materials carried in solution by the rivers?"

"I remember," said Donald. "Is acid one of the things in solution?"

"Yes, and it is the acids in the water that help it to dissolve so much rock and carry it away in solution."

"But it can't get at this rock to dissolve it," said Donald, "only on the top and along the sides of the quarry."



"Let us look at the side of the quarry more closely," said Uncle Robert.

"It is stratified above," said Frank, "just like our limestone."

"And see," said Donald, "how thin the layers are near the top. They are thicker lower down, and then it isn't stratified at all. It is just one solid mass of rock."

"Look at it carefully and see if you can not discover the seams below as well as above."

They walked over to the wall of stone and examined it. Then they went to see the workmen taking out the big slabs.

"See the piece," said Frank. "It didn't look stratified a bit until they broke it, but the stone comes out in layers every time. It must be stratified, only the lower layers fit more closely together than they do on top."

"Look at the place from which that slab was taken," said Uncle Robert.

"It seems to be covered with fine sand," said Frank.

"What do you think happens when it rains here?"

"The water runs down between those loose layers of stone," said Frank, pointing to the top of the quarry.

"How far down does it go?"

"Oh, just where there are cracks," said Donald.

"It can go a long way down here," said Frank, "where the cracks go up and down."

"Those cracks that run up and down are joints," said Uncle Robert, "and, as Frank says, where there



is a joint in the rock the water can enter freely. But it also makes its way into the solid rock. There is no rock so firm that water can not penetrate it, and where there is sufficient water rocks as well as soil become saturated."

"What do you mean by saturated?"

"Completely filled, so that they can hold no more. Now, as the water makes its way down into these joints and creeps along between the strata, what happens?"

Frank looked at the piece of stone in his hand, upon which they had poured the hydrochloric acid. Then he looked at the place from which the workmen had taken the slab of stone.

"Did you say, Uncle Robert, that there is carbon dioxide in all the water that runs down into this rock?" he asked.

"That is what I said."

"And you said that the carbon dioxide dissolves the lime in the rock, didn't you?"

"Yes."

"Well," said Frank, slowly, "if the lime is taken out of the rock, the sand must be left. That is how that loose sand came between those slabs. And of course if something is taken out the crack must be made bigger."

"And so the water has a better chance to creep in," added Uncle Robert. "Yes, that is just what happens. The water, containing acids, creeps into the joints and cracks, eats out the lime, and leaves the loose sand.

"This goes on year after year, and the more lime that is taken out, the more cracked and broken the rock becomes, until finally it is only fine sand once more for the rains to wash into the streams, and the streams to carry away to the sea."

"Will it be made into rock again in the sea?" asked Donald.

"It may not be sandstone again, but that which is dissolved and carried away in solution will help to make other rocks."

"Isn't it wonderful!" said Frank. "Nothing seems to be lost, but everything changes and helps to make something else."

"That is the truth, Frank," said Uncle Robert. "This earth upon which we live is constantly changing, but not an atom, which is the smallest particle of a thing known, is ever destroyed."

"Is lime the only thing that acids can dissolve?" asked Donald.

"No, every acid which water carries helps dissolve some of the substances found in earth."

"It seems to me," said Frank, thoughtfully, "that the rivers must carry away more in solution than they do in any other way."

"Some rivers do, Frank," said Uncle Robert. "I have read how much rock is carried away in solution by different rivers in one year. If I could tell the figures, you would be astonished."

"I should think there wouldn't be any rocks left," said Donald.

"And yet the change is so slow that we can not

see it," said Uncle Robert, "although there are other things at work to wear rock away besides this chemical action."

"What are they?" asked Frank.

"In the winter when it is very cold, what happens to the water that is in the cracks of the rocks?"

"It freezes."

"And what does water do when it becomes ice?"

"It swells," said Donald. "I know, for I left a pail of water out one night and it froze and broke the pail all in pieces."

"Sometimes in the spring we find the fence-posts loose," said Frank. "Father says it is because they are not set deep enough and the frost gets under them and lifts them up."

"The same thing happens when water freezes in the joints and between the strata of rock," said Uncle Robert. "The ice swells and makes the rock larger. Then in the summer more water runs in with its acids to eat away the rock. The next winter it freezes again and the cracks become greater. So year after year the cold in winter and the heat in summer keep up their unceasing labor until the hard rock is changed to loose sand for the winds to blow about and the waters to wash away."

"Would rock always stay just as it is if there were no water in it?" asked Frank.

"No, even dry rocks are affected by the changes of temperature. You remember what we learned with our thermometer about the air."



"We learned that when the air becomes hot it expands," said Donald.

"And it contracts when it is cold," added Frank.

"So it is with the rocks. As the hot summer sun shines upon the earth, the surface layers of rock expand. Then the cold of winter causes them to contract. In some places, particularly upon high mountains, the difference in the temperature of day and night is so great that as the rocks contract at night pieces are broken off with a noise like the firing of a gun. As only the surface layers of the rock are affected this way, you can see that the constant movement caused by the expansion and contraction would loosen them from the rock beneath."

"That would help the water to get into the rock," said Donald.

"And so keep up the work of changing the hard rock into soil."

They left the quarry and went to the top of the hill. As they looked down upon the river and the dam, Frank said:

"It is all gneiss down there, and up here it is sandstone."

"If we could look under this sandstone we should find the gneiss just as we see it down there," said Uncle Robert.

"You said that this rock was once soft sand," said Frank. "I should like to know how it was changed."

"I can tell you something about it, but it is a long story. All the land upon the earth has at one time or another been under the ocean. You remember



what I told you about the rising and sinking of great masses of land? As soon as a land mass rises above the surface of the ocean, all the things which we see working here begin to wear it away. The heat, the cold, the rain, the rivers, all work together to level it off, mountains and all."

"But can they do it?" asked Frank.

"They have kept at it in a remarkable way. For thousands, probably millions of years, they have worked on, and gradually the mountains have become lower and the earth spread out on the bottom of the ocean has become thicker. Some of this earth on its way from the mountains to the ocean was ground into very fine mud. A great deal of it was sand such as we can see on that bank yonder. Often pebbles and large stones reached their resting-places without being worn to sand or to fine mud. All was spread out on the floor of the ocean. Sometimes there were layers of pure sand hundreds and thousands of feet thick. Then there might have been a layer of the mud. Then possibly a layer in which the fine mud, the sand, and the large stones were all mixed together. These were the materials brought down by the rivers in suspension. Now what do you think became of that in solution?"

"Was the lime in solution?" asked Frank.

"Yes."

"Then it must have settled down into the sand and made a cement to stick it together."

"Have you ever seen lime used as a cement to stick sand together?"

"Oh, yes, in plaster. And when it dries it is as hard as stone."

"You said there were layers of mud," said Donald. "Was it all made into sandstone?"

"No; the sand cemented sometimes by lime, sometimes by other things, made sandstone. The fine mud became shale and the coarse pebbles and stones compacted into solid rock by lime or other cements made conglomerate."

"Did any of it get to be limestone?"

"The story of the limestone is the most wonderful of all," replied Uncle Robert. "When the rivers reach the ocean, the lime carried in solution is taken from the water by a great many little animals. Those we hear the most about are called polyps, and the beautiful coral which we admire so much is simply the dead polyps."

"Why, uncle," said Donald, "the coral I saw once was like stone. It didn't look like a dead animal."

"No; but it was the lime taken from the ocean by the little polyp when it was alive. You have heard of coral reefs. These banks or reefs of coral extend for miles beneath the sea, where they grew as polyps. There is nothing more beautiful than a living coral reef. Looking down through the clear water, one can see the most wonderful forms in all the colors of the rainbow. It is like a rare flower-garden blooming under the sea. But the little polyps are very particular about where they live. Four things are necessary to their life—warm water, salt water,

water in action, and light. Of course they find the salt in the ocean, and they never live where the water is colder than sixty-eight degrees. Then they do not live in the deep parts of the ocean, for there they would miss both the light and the moving water."

"But, uncle, isn't coral ever found in the deep ocean?"

"Yes, very often. I have told you of the rising and sinking of the land. If the land sinks slowly, the polyps continue to grow at the top, and so they keep in the required depth of water. They constantly die at the bottom, and then they are coral."

"But what if the land rises?" asked Donald.

"The polyps die and there is no more growth."

"Then what happens?"

"Then the waves and rains beat upon the frail coral. It soon breaks and crumbles and falls into the sea, where it becomes hard limestone."

"How does any one know that this is true?" asked Frank.

"By the pieces of coral that are found imbedded in a great deal of the limestone. Fossils of other little animals are also found."

"Doesn't the lime in the water ever become stone without first being part of some of these animals?" asked Frank.

"Some geologists think it does," was the reply. "You know if you dissolve salt in water and let it stand until the water evaporates the salt is left. This may be so with lime; but of course it could not happen in the ocean. It must be in some inland body



of water, if at all. It is also thought by some that limestone is formed by a settling to the bottom—precipitation, as it is called—of the lime. Now I have told you the theories of making sandstone, limestone, conglomerate, and shale.”

“What is shale?” asked Frank.

“It is stone formed by heat and pressure from very fine sediment, such as clay. After a great deal of pressure and heat it becomes slate.”

“Like the slates we use in school?” asked Donald.

“Yes. Your slate was once fine mud.”

“What made the mud harden?”

“Uncle Robert told you that heat and pressure did it,” said Frank.

“Yes; but what pressed upon it, and when was it so hot?”

“You can answer that question, can’t you, Frank?” said Uncle Robert.

“I can answer the first part of it. The pressure may have come from the mud, sand, and gravel above bearing down on the layers below. You said that this material may have been hundreds of thousands of feet thick. But I don’t know about the heat.”

“Do you remember what I told you about the mine I went into once?”

“You said that it was so hot that no one could have lived in it without the cool air brought in from the outside.”

“Yes; volcanoes tell us that deep down in the earth it is hot enough to melt granite. If we go down for a distance of about four thousand feet from the



surface, we find that the temperature increases at the rate of one degree for every fifty-seven feet. Although this rate varies considerably in different places."

"But how did the mud come to be down there where it is so hot?"

"When a great mass of sediment is deposited in one place it makes the earth's crust sink under the weight. But you must not think that heat and pressure have the most to do in making rock. Probably the best rock manufacturer is the water which carries materials for cement in solution. Sand, gravel, and mud are cemented into rock by these substances in water."

Donald rose from the ground where they had been sitting as they talked, and walked to the edge of the quarry. When he came back he said:

"But, Uncle Robert, if sandstone was formed in the ocean, how did all this stone come here?"

"The ocean was right here once, Donald."

"That must have been when the Rib was such a high mountain, before the glacier took the top off," said Frank.

"Yes; long before the great ice-cap this land lay hundreds and thousands of feet under the ocean. Then it was lifted up, and this sandstone which was once the bottom of the ocean became dry land."

"I wonder if there is much of this sandstone," said Frank.

"It extends for many miles," replied Uncle Robert. "In fact, it reaches far down into the State of Illinois. It is said that the water which falls here

is carried in this sandstone clear down to Chicago. There it is more than a thousand feet under the surface, and on top of it is a great mass of limestone."

"Is it under our limestone at home?" asked Donald.

"I think so."

"How can they tell what kind of stone lies under another when it is so thick?" asked Donald.

"They tell by boring wells. But see what has happened to the sky while we have been talking."

"It is all clouded over," said Frank. "It looks like rain."

"Let's go fishing, Frank," said Donald.

"We'd better fix our tent first," said Uncle Robert, "so we shall be ready for the rain if it comes."

"How shall we fix it?" asked Donald.

"We must pin it down carefully and dig a trench around it to carry the water off."

"Oh, won't it be fun!" cried Donald. "I hope it'll rain hard. Come on, Frank, I'll get to the bridge first."

Away down the hill they ran, Uncle Robert following closely after.

## CHAPTER XV

### THE FLOOD

It was night when the storm came. The three travelers were wrapped in their blankets with the canvas walls of the tent to shelter them.

"It's coming," said Frank, raising his head as a flash of lightning made their surroundings visible.

The lightning was followed by a low, distant rumble of thunder.

"The lightning always comes before the thunder," said Donald.

"Why is it so, uncle?" asked Frank.

"When a gun is fired, which comes first, the flash or the sound?"

"The flash, but I don't know why."

"It is because light travels through the air more quickly than sound."

The lightning grew brighter. The thunder followed more rapidly than at first.

"You can tell how fast the storm is coming," said Uncle Robert, "by counting between the lightning and the sound of the thunder."

A flash came quickly. The boys counted twelve before the thunder followed. Another flash and

another roll of thunder. This time they counted nine.

"It is coming nearer," said Donald.

A few big drops dashed on the canvas roof. Flash followed flash in quick succession. The thunder rolled without ceasing. Then there was a vivid light. It lasted long enough for Uncle Robert to look at his watch and see the time. At the same moment came a crash as though great bombs were bursting in the air. The rain poured down in a flood.

"My, what a storm!" said Donald, drawing the blanket over his head. "But it can't get in here. The trench will carry the water off."

In spite of the storm they were soon fast asleep. They slept securely in their tent, only awakened now and then by a crash of thunder and a vivid flash of lightning.

It rained all night. The lightning had ceased, but the rain poured down steadily. Donald, in rubber boots and coat, crept out of the tent quite early.

"The river is rising!" he shouted. "It is rising fast! Come and see it!"

Uncle Robert lifted the side of the tent toward the river.

"We can see it without getting wet," he said.

"What about breakfast?" asked Frank. "We can't make a fire in this drenching rain."

"It will have to be a cold breakfast this morning," said Uncle Robert; "but no matter, we shall not starve."

So as they sat under the open tent they ate ham



sandwiches and watched the rising flood. It was a fascinating sight. The current moved rapidly. Logs, pieces of boards, timbers, and trunks of trees freshly torn from the banks swept by. Some logs in the middle of the current went down in a straight line. Others left the current and moved toward the shore. Then they turned backward as in an eddy. After two or three turns the main current caught them again and whirled them away. The outside of the eddy was marked by a line of chips and sawdust in the form of an ellipse.

"See the island!" cried Donald, pointing to a bit of low land in the surging stream. "The water is rising around it."

The low beach was already covered. The water was creeping over the grassy banks. Then it flowed about the trunks of the trees. At the same time a broad flat beach below their camping-place was flooded.

"There!" shouted Donald. "It's all under. Those trees are going to have a fine drink."

"It'll do them good to have so much water, won't it, uncle?" asked Frank.

"Trees need a great deal of water," replied Uncle Robert, "but if the water should remain on the ground it would kill the trees in time."

"I thought water was good for trees—the more the better."

"Certainly it is good for them, but it is possible for them to have too much. Trees need something besides water."

"They need air," said Frank; "but they can get that through the leaves."

"Yes, but the trees breathe through the roots, too. There is air in the ground, and many plants have roots especially made to breathe the air from the soil. Cypress-trees, which live in the water, send up roots to the surface to breathe the air which they must have to live."

The rain swept in sheets before the open tent.

"Isn't this a flood, though!" exclaimed Frank. "I'm glad it came, so we can see the river rise."

"How'd you like to be out in that current now?" asked Donald. "Wouldn't it make the boat just skip along!"

"See how those logs swing out toward the shore, uncle," said Frank. "Why don't they keep in the current?"

"There is something interesting about this current," said Uncle Robert. "I don't know whether you can see it or not, but look across the river in a straight line close to the water."

"Why, Uncle Robert," exclaimed Frank, "the water is higher in the current than it is on either side. It is a regular arch."

"Isn't it strange?" said Donald. "I can see it plainly. I don't understand how water in a wide river can flow any way but just flat."

"Can you tell now what makes the logs swing out to the sides?"

"Why, of course. The water carries them."

"It seems as if the water slopes toward the banks,"

said Frank, his eyes on the river. "I think the water on the surface flows off the slope and carries the logs with it."

"You are right," said Uncle Robert. "You can tell how the water flows by the way the logs move. The current is really very narrow. If the logs are exactly in the middle of the current they are carried straight down; but when they are a little to either side, the movement of the water toward the banks takes the logs with it."

"Who would ever have thought it would do that way?" said Donald.

"There are many things we never would have thought of without seeing them," said Frank.

"Now I can tell you something more," said Uncle Robert, "which you can not see. Perhaps you can not understand it, but I will tell you. The water in a river does not flow straight along as it seems to do."

"You will surely have to tell us about that," said Donald.

"You see how these logs turn around in the eddy before they go on down the stream. You can see that the logs move in the same direction as the water does—that is, on the surface. But the water has what may be called a spiral movement. It flows out from the current on the surface, sinks down when it reaches the shore, turns backward a little, and flows toward the current again on the surface. It is a movement something like this," moving his hand in the form of a spiral.

"Do you mean that the water flows round and



round, this way?" asked Frank, making the motion as Uncle Robert had done.

"Yes; and that is what is called a spiral movement."

"It is like the groove in a screw," said Donald.

"Yes; that is in the form of a spiral," said Uncle Robert.

"As the water flows down-stream there must be a spiral on each side of the current," said Frank, "for the logs move off on both sides. But, oh, dear, I shall get all mixed up!"

"I'm all mixed up now," said Donald.

"You need not allow this to confuse you, boys," said Uncle Robert. "You will understand it when you study more. I tell you now because it has much to do with the work of the river in grinding up the earth and rocks."

"I should think the water would be always muddy and stirred up if it flows that way," said Frank.

"How muddy it looks now!" said Donald. "There must be a lot of earth going down."

"Yes," said Uncle Robert. "We know that during a flood the river does the most work. But where does the river get all this load of earth it is carrying?"

"I know," said Donald. "It gets it from all the high banks above here, and from all the tributaries."

"And from the tributaries of the tributaries," said Frank; "the little creeks and brooks."

"Anywhere else?"

"It is running right down this slope without any



channel to flow in," said Donald, looking out of the tent.

"It must be running off all the fields in the same way," said Frank.

"That's the way it does on our fields at home," said Donald.

"This rain may be falling over the entire river basin north of us," said Uncle Robert. "If so, every square foot of land in it is giving up some of its soil. It may not all come down the river to-day, and perhaps not during this flood, but it will start and go a little nearer to it than it was yesterday. The rain dashes down on the earth, and the loose particles, the dust on the grass and in the air, are all swept away."

"The land gets a good washing," said Donald.

"Where do you think the most soil is washed away?"

"Where there are no grass or bushes; where the ground is bare," said Donald.

"Why is that?"

"Roots always hold the soil," said Donald.

"They keep the rain from running off so fast, too," said Frank.

"What does it do, then?"

"It soaks into the ground."

"Suppose it falls upon a plowed field."

"Then it runs into the furrows and carries away a lot of earth. I've seen it on our fields often."

"That is true if the furrows run up and down a slope. But how would it be on a hill if the furrows run around the slope as they always should?"

"The water would run into the furrows and stay there," said Frank. "It couldn't get out. It would have to soak in."

"It has been proved," said Uncle Robert, "that land plowed in the fall, with furrows running in the direction to prevent wash, has more water all summer than any other. The loose, open soil and the uneven surface allow the water to soak down to a greater depth. But, as you say, if the furrows run in a direction to carry the water off, the wash on a plowed field is very great."

"But where the rain falls on the grass there is less wash, and where there are bushes they hold the water back," said Frank.

"And the trees do, too," said Donald. "You know how long you can stand under a tree in a shower before the water begins to come through."

"What do you find under the trees in the woods?"

"Dead leaves. The ground in our woods is covered with them."

"Does the water soak through them quickly?"

"Not quickly, but it gets through after a while. The ground is always damp in the woods," said Frank.

"Where the rain-drops fall upon bare earth they strike with a little blow, and each drop disturbs a few grains of soil. Where there is grass it protects the soil; and the bushes, the trees, and the dead leaves do the same."

"Then when all this country was covered with the great forests the floods did not come so quickly as they do now, did they?"

"Why?"

"Because the trees kept the rain from falling so heavily and it had a chance to soak in. Now where the timber is cut down and only stumps are left, much of it must run off at once. That's how a flood comes in just one night."

"What do you think will be the effect of cutting down the forests?"

"I should think that after a while all the good soil would be washed into the streams and be carried down this river."

"It won't be lost," said Donald. "It will go to make flood plains somewhere else."

"But that stump country will not be good for much," said Frank.

"I'd like to know just how many pounds of earth are going by us now," said Donald.

"You could never find that out," said Frank.

"Measurements have been made," said Uncle Robert, "of the amount of earth carried down by rivers during a day and even an hour."

"Uncle," said Frank, after a moment's thought, "the rain that falls on the woods must do a great deal more good than what falls on the fields?"

"What makes you think so?"

"In the woods it has a chance to soak in, and most of it runs off the fields."

"What do you think about that, Donald?"

"I think it soaks into the fields, too," said Donald.

"Suppose the earth were smooth and hard as tin?"



"Oh, wouldn't the water just run off!" cried Donald.

"What would happen if every drop of this rain ran down into the river?"

"It would make a flood worth seeing."

"Then when the rain was over, what would happen?"

"In a little while all the water would be gone. There wouldn't be any more to run," said Frank.

"Then there wouldn't be any river," said Donald, "only when it rained. I'm glad there isn't a tin roof on the earth."

"Or even a canvas one," laughed Frank, springing up as the water began to drip through on his head.

"That's the first leak we've had," said Uncle Robert, "and the ground is quite dry in here."

"The trench has worked first-rate," said Donald, going to the side of the tent to look out. "Just see how the water is running down in it!"

"It has really been worn deeper already," said Frank.

"If this rain keeps on, the trench may become like the moats around the old castles in the middle ages," said Uncle Robert, smiling. "You've read about them; haven't you?"

"Oh, yes," said Donald. "We'd be knights and the tent would be our castle."

"We'd have to have a drawbridge over the moat," said Frank.

"Wouldn't it be great!" cried Donald. "It would be more fun than the wigwam we used to have



down by the creek. I'd rather be a knight than an Indian."

"Well," said Uncle Robert, looking at the clouds, "I think our trench will not be deep enough to need a drawbridge. The rain is almost over."

While they were talking the clouds had grown higher and thinner and the rain fell less heavily. But the river had risen steadily and the curve in the current had become more marked.

"Whoever would have thought of such a thing!" said Frank. "Isn't it wonderful?"

"Is it that way only in a flood, uncle?" asked Donald.

"We did not see it before, did we?"

"Oh, no. It must be the flood that makes it."

"How do you suppose it is when the river is very low?"

"Why, it would be just flat. There wouldn't be any curve at all."

"On the contrary," said Uncle Robert, "it would curve the other way. The current would be the lowest part of the stream."

"Then the water from the banks would move into the center of the river, wouldn't it?"

"Yes."

"Would there be any spiral to it, then?"

"There would be a spiral, but it would turn the other way."

"Hurrah!" cried Donald. "There's the sun! The rain is over. Let's make a fire and have dinner."

"I'd like to know how we can make a fire now," said Frank.

"How would you like to go into the town and have dinner at the hotel?" asked Uncle Robert.

"Oh, good!" said Donald. "I'm starving. Hurry up, Frank. Don't stop to do a thing. The tent will be safe, won't it, Uncle Robert?"

"I think so. We won't be gone long."

"I don't know about that," said Frank. "I feel as though it would take a good while for me to get enough to eat."

"Let's go," said Uncle Robert, laughing. "It frightens me to think what might have happened to you if the rain had lasted much longer."

## CHAPTER XVI

### AFTER THE FLOOD

THERE was never a better dinner; at least so thought the boys. Not a course was omitted; not a dish declined. As they lingered at the table Uncle Robert looked from one to the other with a smile.

"Well, boys," he said, "would you like to exchange the tent for the hotel?"

"Not I," said Frank, quickly. "I'm ready to go back to the tent now."

"So am I," said Donald, pushing back his chair; "but that was a good dinner."

They all felt better as they went out into the streets, now flooded with bright sunshine.

"The streets are drying already," said Donald. "See how they steam."

"Just see how the rain has made little gullies all over the road," said Frank.

From the middle of the street, on either side, the ground was lined by tiny channels cut by the water as it ran off. Starting from the highest part of the roadway, they wound about until they were lost in the gutter.

"Here we can see river systems in miniature,"

said Uncle Robert. "There in the middle of the road is the water-parting, the high land from which the rivers flow. You see it is not a straight line. Some of the rivers that flow to the left start over on the right side, while others do not even reach as far up as the middle of the road."

"And see," cried Frank, "all of the rivers have tributaries, and here is one with a delta where it flows into the gutter."

"Isn't it queer," said Donald, "to think of these little gullies made by one rain as being like real rivers thousands of years old. I should never have thought of such a thing."

"The more you study, Donald," said Uncle Robert, "the more you will discover that the best way to know big things is through studying the little things that lie all about us."

"Quite a storm, sir," said a man, joining them as they stood looking at the muddy water flowing through the gutter.

"We found it so in our tent down by the river," replied Uncle Robert. "Do you often have such heavy rain at this time of the year?"

"As to that," answered the man, "rain's a thing that can't be depended upon as to time or seasons, although they do say there are places where it comes as regular as clockwork. But here we have to take it just as we get it. If you want to see some lively work, sir, just walk over to the east side of the town."

"What's going on over there?" asked Frank.

"Oh, the culverts are all washed away, and at



one time it seemed as though some of the bridges would go. But I think that the worst is over now. It's a good sign to have it clear about this time of the day."

"Let's go and see the culverts," said Donald.

They bade their new acquaintance good afternoon and set out for a walk through the town. Everywhere they saw the work of the storm. The gutters were full of water running rapidly down the slopes and the open culverts were overflowing.

"No wonder the river is rising," said Frank, "if the water is running into it everywhere as it is here."

"But this won't last long," said Donald. "Now that the rain is over the water will soon run off."

"What will the river do then?"

"It will go down."

"What do you mean by go down?"

"It will look as it did before it rained."

"What feeds the river when there is no rain? Sometimes there is a long drought, but still the river flows on."

"You told us the river is fed by lakes," said Donald. "They give it water even in dry weather."

"What feeds the lakes?"

"Oh, the rains and the melting snow."

"The lakes are reservoirs for the rivers," said Uncle Robert, "but they are easily drained. There is a reservoir much larger and more certain than the lakes."

"There is a great deal of water in the earth," said Frank. "Do you mean that, Uncle Robert?"

"Oh, yes," said Donald. "We know it soaks into the ground."

"It even soaks into the rock, too," said Frank. "Don't you remember how it was in the quarry?"

"There it runs down into the cracks and joints; but it doesn't soak into solid rock like gneiss, does it, uncle?" asked Donald.

"Even the hardest rocks are more or less porous; that is, they all have little holes or interstices in them into which water can penetrate."

"But the soil will hold more water than rock," said Frank.

"What kind of soil holds the most water?"

"It isn't sand," said Donald. "Water runs right through sand."

"How is it with clay?"

"Oh, it can't run through clay so easily," said Frank. "You see sand is a kind of loose soil. There is room between the grains of sand for the water to go. But the clay is much finer. The little grains or particles fit so closely together that even water can't get through."

"The earth is full of these little interstices."

"That's a big word," interrupted Donald. "What are interstices?"

"They are the holes or very small spaces between the irregularly shaped particles of rock that make up the soil. The finer these particles are, the closer they fit together and the smaller are the interstices."

"That is why the water doesn't run through clay," said Frank. "The—the interstices are too small."

"What is in these interstices before the water fills them?"

"Oh, nothing. That is why water runs in so easily."

"You are mistaken about that, Donald. Every space not filled by something else is filled by air."

"But what becomes of the air when the water soaks in?"

"Some of it goes down into the ground with the water. Soil without air is useless. But how about the water? You saw in the quarry how it goes down into the rock."

"It works down through the joints and between the strata," said Frank.

"Everywhere there are joints in the solid rock, and in some places they are very wide."

"The water must go a long way into the earth," said Frank.

"It does."

"A thousand feet?"

"Many thousands of feet."

"It is hot deep down in the earth," said Donald.  
"I should think the water would boil."

"It does boil."

"Does it make steam?"

"Yes, and often the steam bursts up through the crust of the earth. In many places there are deep holes, like the craters of volcanoes, which are caused by the explosions of steam. In mining, one of the greatest difficulties is from the water which rushes into the mines. So you see we have many proofs



that there is much water far below the surface of the earth."

"But if the water goes so far down," said Frank, "how can it get into the rivers?"

"A great deal of it stays near the surface."

"What keeps it there?"

"Perhaps I can explain it better by drawing," said Uncle Robert, taking his note-book from his pocket. "Let us sit down on this log."

They had walked back to the river near an old mill where the banks were lined with logs. They sat down and the boys looked eagerly over Uncle Robert's shoulder as he drew.

"This," said Uncle Robert, "is a cross-section of earth, such as may be seen in railroad cuts. Now, as the rain falls what happens?"

"It soaks through the loam and sand quickly," said Frank.

"And the gravel," added Donald. "What about the clay?"

"Oh, it can't get through it so quickly, but it soaks in after a while."

"It soaks into the clay and fills up all the little spaces or interstices. Then the clay is no longer permeable."

"What does permeable mean?"

"Any substance through which water can soak is called permeable. Soil through which water will not pass is impermeable."

"Then when all the little spaces in clay are filled with water it is impermeable because the water can go no farther."



"Yes."

"What does it do then?" asked Donald.

"It either has to run along on the clay or fill up the ground above it. Suppose it did fill up clear to the top, what would there be?"

"I think that would be a swamp."

"If the clay were perfectly level, with layers of gravel, sand, and loam spread out evenly over it, what would there be, provided there were rain enough?"

"The whole earth would be a swamp."

"But we know that it is not so. Most of the surface of the earth slopes one way or the other, and we can see by the outcropping of the gneiss all along the river that the rock under the surface slopes, too. Now I will draw another figure. This," pointing to the figure, "is the impermeable stratum. What will the water do when it reaches it?"

"It will run down the slopes."

"As we see it running over the surface of this hill?"

"Yes, only a great deal more slowly. It has to work through the soil that lies on top of that rock."

"Where would it go?"

"It would go down to the bottom of the slope."

"Oh, I see," cried Donald. "It would come right out of the ground there."

"That would make a spring," said Frank.

"Is that how our spring is made?" asked Donald.

"I think so."

"The limestone is under our farm," said Frank, "and it slopes down to the hill, where it comes out."

The water soaks down through the soil until it comes to the limestone. Is limestone impermeable, uncle?"

"Yes."

"Then the water flows along on the limestone until it comes to the hill. Then it comes out in our spring."

"Why doesn't the water come out all along the hill?" asked Donald. "The limestone does."

"For the same reason that water does not flow evenly all over the surface of the earth."

"That is because it runs off the hills into the valleys and makes streams," said Frank.

"There are streams underground, too."

"Like our creek or this river?"

"There are caverns and underground waterways, such as there are under glaciers. But generally the water soaks or percolates slowly through the soil, always moving toward the lowest places where it often wears away a channel, or, if it can find an outlet, forms a spring."

"I should think there would be a great many springs along rivers."

"Why?"

"Because if the river cuts down its banks to the permeable rock the water has a chance to get out."

"You will find that rivers and lakes are fed by just such springs."

"Is it a spring that feeds our swamp?" asked Donald.

"What do you think about that, Frank?" asked Uncle Robert.

"It seems to me," said Frank, thoughtfully, "that

our swamp is like the place you told us about a little while ago. The impermeable rock is covered by loose earth that is permeable. So it just soaks full of water and makes a muddy swamp. If the impermeable rock came to the surface there might be a spring."

"Now can you see what the great reservoir of the rivers is?"

"Yes, it is the earth itself."

"If the surface of the earth were hard, like tin, the water would rush away when it rained, and do no good. But it sinks down into the earth and the earth holds it and lets it out slowly to feed the rivers and keep the trees and plants beautiful."

"But if there are always strata that are—what did you call it?—impermeable," said Donald, "how does the water get away down thousands of feet into the earth?"

"Don't you remember?" said Frank. "There are joints in the impermeable strata where the water can go through."

"But are the joints thousands of feet deep?" asked Donald.

"Often a joint extends through but one stratum of rock, but under this stratum of impermeable rock there may be rock that is permeable. Can you see what would happen then?"

"The water would soak or—what did you call it?—percolate through the permeable stratum."

"Then under the permeable stratum there is often another that is impermeable."



"Then the water couldn't go any farther down."

"What would it do?"

"It would work its way along in the permeable rock."

"Now I will draw another figure," said Uncle Robert. "You remember I told you that the sandstone we saw in the quarry extends clear down under Chicago."

"Yes," said Donald, "and on the top of it there is limestone hundreds of feet thick."

"It goes under our farm, too," said Frank.



Fig. 12.—Section showing rock strata.

"Well, now I will draw a figure to show how this sandstone may run." (Fig. 12.) This point," he continued when the drawing was finished, "we will call Stevens Point, where the sandstone is the surface rock. Over there will be Chicago, where the sandstone is overlaid by the limestone. This sandstone is more permeable than either the limestone above or the layer of rocks beneath. Can you tell what the water does?"

"The rain that soaks into the sandstone here at





Stevens Point must work its way down along that stratum. It might go as far as Chicago if there were enough of it and it had time," said Frank.

"What do the impermeable strata above and below the sandstone do?"

"They keep the water in the sandstone."

"But, Uncle Robert," exclaimed Donald, "you are just supposing, aren't you? This really isn't true?"

"No, I am not supposing, Donald."

"How can any one know that this is true?"

"By boring wells. There are artesian wells in the region of Chicago, which get their water from this same sandstone. They bored down, down through the limestone, and when they came to the sandstone the water gushed up."

"And that is an artesian well," said Frank.

"But they didn't have to bore over a thousand feet before they found water, did they?" asked Donald. "Our wells are only about thirty feet deep, and we have plenty of water."

"It doesn't run right out at the top, though," said Frank. "We have to pump it."

"What is a well?" said Uncle Robert.

"It is a hole in the ground with water in it," answered Donald.

"I see how it is," cried Frank. "They dig down in the ground till they come to the hard stratum over which the water percolates."

"Then the water runs into the hole that is dug," said Donald, "and that makes a well."

"You say you have two wells about thirty feet deep," said Uncle Robert. "Do they always have water in them?"

"No; they did dry up once last summer, but that was because there was no rain for ever so long."

"How are they when it rains a great deal?"

"Oh, sometimes they are about half full, but the water never comes clear to the top."

"Is there any place on your farm where it does come to the surface?"

"Yes, the swamp in the woods."

"Is it always the same there?"

"Oh, no; there is more water when it rains than when there is a drought."

"Then the surface of the water underground seems to rise and fall just as it does in the river."

"It must; for it surely is higher sometimes than others."

"That is, the ground is saturated to the surface at times. Then this level of saturation, as we will call it, falls far below the surface if there is less rain."

"Yes; it must be always changing, just as the water on the surface is."

"But there is one thing that puzzles me," said Frank. "We know that plants can't live without water. Now suppose the saturation level is away down so low that our wells have no water. That is thirty feet. How do the plants live?"

"That is a good question, Frank," said Uncle Robert. "I am glad that you have come to this problem——"

"Oh, is it a problem?" exclaimed Donald, laughing. "That means that we must work it out ourselves. Let's not do it now, uncle."

"I think it would be better to leave it," replied Uncle Robert, "until we go home. Then we will have some experiments to show how the water rises above the saturation level to feed the plants."

"Rises!" exclaimed Frank. "Well, that is a puzzle. I thought water always sank."

"We are going to leave it until we get home, Frank," said Donald, getting up and walking toward the river. "Let's go back to the tent now."

## CHAPTER XVII

### BELOW STEVENS POINT

FROM Stevens Point to Nekosa the outcropping of the gneiss causes a succession of rapids, broken in many places by dams. The current is swift at all times, but the force of the flood added much to its swiftness. It was hard work to keep the boat in the current. They could think of nothing else as they plunged through the surging water. Then came a dam, where the boat had to be drawn around on land. Then more rapids and another dam. It was a day full of excitement and hard work, but by evening they reached Nekosa where the rapids end. They were safe and sound, but very tired.

"I'm glad that's the last of the rapids," said Donald. "It's great fun, but it's hard work."

They camped below the dam. Frank said it was the largest dam they had seen on the river. Near by was a paper-mill, which they visited the next morning, and saw how paper is made from wood.

That evening they were too tired to do anything but sit beside their tent, from which they had a fine view of the falls caused by the water rushing over the dam. Frank took the field-glass and scanned the opposite shore.



The rapids.



"What kind of rock is that over at the other end of the dam?" he asked. "It isn't gneiss."

"What does it look like?"

"It looks like the quarry at Stevens Point. But they wouldn't build a dam with one end against sandstone, would they?"

"It seems a dangerous experiment. But that is what they have done."

"The sandstone will be sure to wear away first," said Frank. "Then down will go the dam."

"Are there any dams below here?" asked Donald.

"I do not know," said Uncle Robert, "but I do know that we shall find much sandstone. I am told there is little, if any, gneiss."

"That is why there are no rapids," said Donald. "I think I'll like it better."

"All the way from Stevens Point it made me think of Mosinee," said Frank. "Will these rapids ever wear down to a smooth bed, uncle?"

"Yes; some day there will be no rapids here."

"I don't see how you can know that, uncle," said Donald. "Did you read it in a book?"

"The story is written very plainly in our Big Book, Donald," said Uncle Robert. "Do you remember?"

"Oh, yes," said Donald; "but please tell us how to read this story. I can't do it by myself."

"I can tell you better with my pencil," said Uncle Robert.

He took out his note-book and drew a zigzag line across the page. (Fig. 13.)

"This is the river channel," he explained. "You see it is very rough and uneven. You remember how the boat went up and down as we came along."

"I sha'n't forget it soon," said Frank. "My arms ache yet."

"Here at Nekosa we find the last of the hard rock. Below here the flow is smooth and steady.



Fig. 13.—Longitudinal profile of river-bed.

Now where do you think the most cutting is done by the river?"

"I think right here at Nekosa at the end of the rapids," said Frank.

"Why?"

"Because just below here the rock is softer. The water rushes over this hard rock down upon the soft rock and cuts it away."

"Yes; and it may cut down so far that there will be a fall here some day. Then the cutting will work back up the river."

"But is this the only place where there is any cutting?" asked Donald.

"Oh, no; it cuts all the way along, but the most is done here."

"That is because the rock above here is so hard."

"What happens in the low places in the river-bed?" asked Uncle Robert.

"They must fill up some with the earth brought down by the river," said Frank.

"How does that affect the channel?"

"It helps to even it up. Just this way."

Frank took the pencil, and over the line Uncle Robert had drawn drew another one.

"You see, while the high places in the bed are being worn off the low ones are being filled up; so it must be growing smoother all the time."

"Doesn't it wear away in the low places?"

"It can't wear away and fill up at the same time, can it?"

"I don't see how it can."

"But suppose the places that are being worn off become lower than those that are being filled up?"

"Then they will be worn away, too, until the whole bed is as low as this place here below the falls."

"Then there won't be any falls."

"No, the bed will be a gradual, even slope like this." Frank drew a line with an even concave curve over the line representing the river-bed.

"Oh, dear, I'm so tired," said Donald. "Let's go to bed."

The next morning they were up early, and after visiting the paper-mill, were off on the river again. The flood was in full force. Many islands and flood plains were under water. They could row in among the trees growing on the flood plains; but the water moved slowly there, and they preferred to keep in the current, which was strong and steady and carried them along swiftly.



The river became wider and wider. No more gneiss was seen. The banks were of fine sand. There were wide flood plains and beaches, all of fine white sand.

"How much wider the river is here than it is above!" said Frank.

"That's because there is more water in it," said Donald.

"There is another reason," said Uncle Robert. "Where did we find the narrowest part of the river?"

"At Mosinee," said Donald; "but that was because the rock was so hard."

"Oh, I see why it is wide here," said Frank. "These banks are all sand and the river can cut them away without any trouble at all. It isn't always just a lot of water that makes a river wide, is it?"

"I think we will find this river a great deal narrower miles below here than it is here. Can you tell me upon what the width of a river depends?"

"For one thing," said Frank, "the width of a river depends upon the kind of soil it goes through."

"But what makes this river curve so much more here than it does farther back?" asked Donald.

"There is a good reason for that, too," said Uncle Robert.

"It must be for the same reason that it is wider," said Frank. "The soil is soft and loose and easily cut away."

"That is doubtless true," said Uncle Robert. "A river curves much more where the soil is soft than where it has to make its way through hard rock."

They rowed by many low islands covered with trees, and once the boat stuck fast on a sand-bar.

"These islands were all sand-bars once," said Frank. "They are what you called choked islands."

"It is so sandy here," said Donald. "The land must be very poor for farming."

"That must be why we see so few farmhouses," said Frank.

"Everything is different down here," said Donald. "The river is wide and full of curves and islands; and it is all sand, sand."

"The trees are different, too," said Frank. "The elms are gone, and there are only pine-trees here."

"Oh, look!" shouted Donald, who was steering. "There is a real mountain."

Frank and Uncle Robert turned to see what new discovery Donald had made. It did look like a mountain, such as they had seen in pictures; but it was too low to be a real one. Sharp, bare, rocky points stood out against the clear sky. Ragged and twisted pine-trees clung to the steep sides. Frank took the glass.

"That looks like a sandstone hill," he said.

"Yes, all this country is sandstone."

"That is a strange-looking hill," said Donald. "I wonder what makes it the shape it is."

"It was probably very much higher and larger once than it is now."

"There isn't much left," said Frank.

"What is wearing it away?"

"Rain and snow and frost," said Frank.

"The wind does its share, too," said Uncle Robert. "For many thousands of years all these things have been working on that hill and it is about gone. Some day it will be leveled to the land around it. Now it is what is called a decaying hill."

"If it were made of hard rock like the gneiss, it wouldn't wear down so fast," said Frank.

As they went on Frank said:

"I should think the glaciers would have taken that hill off without any trouble."

"That is an interesting problem for us. Why didn't the glacier grind off that hill?" said Uncle Robert.

"Uncle Robert knows why," said Donald, laughing. "I can tell by the way he looks."

"I'm going to find out," said Frank.

By and by the river became narrower. On each side were high walls of sandstone.

"How plainly the strata show here," said Frank.

"Some of the strata must be softer than others," said Donald, "or they wouldn't wear away so unevenly."

After passing through the high sandstone walls for some distance, suddenly they came upon a long flat plain. Away off in the distance they saw another decaying hill standing like a sentinel guarding the plain.

"It is all sandstone here," said Frank.

"We are coming to The Dalles," said Uncle Robert. "Now, boys, a long pull and a strong pull, and think we may reach there by noon."



They were all anxious to see the sights down the river. For miles there had been little variety in the landscape. Opposite the high curved banks of sand were low wide flood plains covered with trees and bushes. There were many islands, so that they had to watch carefully for a good channel to row in. At some places the river was narrow; then it grew wide again. In one place the current divided; there were really two currents in the river. They took turns in steering so that they might look ahead and see what was coming.

Frank was at the rudder when he shouted:

"There are The Dalles!"

Uncle Robert and Donald looked around quickly. On the left bank of the river they saw a mass of sandstone about fifteen feet high which the cutting down of the river had laid bare. The bank was steep and jagged, crowned with a dense growth of pine-trees.

"No," said Uncle Robert, "I think we are not there yet; but I am sure we must be very near."

"Let's go over and look at that rock," said Donald.

"See," said Frank, as they rowed close to the bank, "how plainly the strata show."

"Yes, it is stratified sandstone," said Uncle Robert.

"But just see the colors in it," said Donald. "It's all red and yellow. It isn't a bit like the sandstone at Stevens Point."

"No, it is a much softer sandstone than that at Stevens Point," said Uncle Robert. "It could not be used for building."



"The strata are as even as if it were the basement of a house and masons had made it," said Frank. "Was all this stone once just fine sand like the sand we find in the river?"

"Tell the story as you understand it," said Uncle Robert.

"First there was hard rock, and it was worn down by the rain and the frost and the river."

"The wearing is called erosion," said Uncle Robert.

"Oh, yes. Then the river carried it into the ocean. Some of it was in solution, and the rest was fine sand like all that on that bank over there. When it reached the ocean it was all spread out on the bottom."

"You have remembered very well," said Uncle Robert. "What next?"

"Then some of the material in solution was lime. This mixed through the sand and was the cement to stick it together. Is that right?"

"It was something like that," said Uncle Robert. "We can not know all about it."

"But what I want to know," said Donald, "is what made such lovely colors. Just look at that place. It is red—many shades of red and yellow and brown. Isn't it pretty?"

"The color is caused by the iron held in the water in solution," said Uncle Robert. "Iron is the great coloring matter in rocks."

They rowed slowly along the sandstone bank, amining it as they went. It was very uneven.

Some thin strata hung out over the water. Others were worn away, making little caves all along. Donald shouted, as he saw a little owl sitting in one of the caves. The owl winked at them as they floated by.

"Are The Dalles higher than this?" asked Donald.

"I think they are," said Uncle Robert. "We shall see soon."

Away off across a flood plain they could see little pinnacles of rock.

"Are those mountains?" asked Donald.

"No; they are not large enough to be mountains, but there are mountains shaped much like them. We shall not see any mountains on this trip, Donald."

"Oh, I wish I could see a real mountain," said Donald.

"I hope you may before very long," said Uncle Robert.

"But how the glacier could have gone over all these little hills and not smoothed them down puzzles me," said Frank.

"Look! Look!" shouted Donald, who was steering now. "I see The Dalles! I see The Dalles!"

Uncle Robert and Frank stopped rowing and looked around. On both sides of the river rose high rocky walls. The uneven strata lay one above another, like piles of masonry. At the top the walls were steep, straight, and bare. Above the middle there was a ledge where a few pine-trees clung. At the edge of the water the rock was worn into curves like great scallops. Many little niches close to the water were filled with piles of fine sand. The water

rippled as it curved in between the high banks. The whole picture was very beautiful.

"Yes," said Uncle Robert, taking up the oars again. "There is no mistaking this. We are at The Dalles."

They rowed in between the high banks. The river became narrower. What looked like a little creek flowed through a cut in the high wall on the left side.

"It looks as if there might be a house up there," said Uncle Robert. "Steer us into the creek, Donald, and we'll see. Perhaps we can find out about the river below."

Soon after entering the creek they saw a house high up on the bank. It had a big sign, "Restaurant," over it. As they were tying the boat a man came down from the house.

"The river is pretty high," said Uncle Robert in greeting.

"Yes; it is quite a flood."

"What place is this?"

"The Witches' Gulch."

"What a name!" said Donald. "Do witches live in it?"

"I've never seen any," said the man; "but I can't say what might have been here before my day. It looks as though witches had been at work in some parts of it."

"I think the water made it," said Frank, pointing to a stream of water that flowed through the narrow creek-bed.

"After we have been down to Kilbourn City, we will come back and visit the Gulch," said Uncle Robert. "Can we have lunch here?"

"Yes, sir. Come right up to the house. Are you going to try to row down through The Dalles?"

"Is it hard rowing?" asked Frank.

"Well, you'll have to be pretty good boatmen to row down through the Narrows. I've been a guide on this river and have boated here for years, and it's all I can do even now."

"Perhaps we can get you to take us down," said Uncle Robert. "We are strangers and I don't care to capsize the boat."

"There'd be three less of you if you did," replied the guide.

He agreed to see them safely down, so after lunch they started.



## CHAPTER XVIII

### THE DALLES

DONALD sat in the bow of the boat, Uncle Robert in the stern, and Frank faced the guide.

"I will steer with the oars," said the boatman as he pulled out of the creek.

For years he had been guiding parties through The Dalles and he knew every inch of the river. As he began to point out the strange forms of the rocks Uncle Robert suggested that he let the boys guess the names of the places as they came to them.

"It must have been their shapes that suggested the names to others," he said, "so let us try it."

Soon they came to a little round island that rose several feet above the water.

"Has this a name?" asked Frank.

"It is round like a tub," said Donald. "I guess it is the tub."

"You're not a very good guesser," laughed the guide. "Did you ever see a tub curve in at the bottom as that does?"

"It might be a flower-pot," said Frank.

"Not so bad, young man," said the guide; "but 'bat isn't it either. It's the Inkstand."



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Inkstand and Sugar-Bowl.

"The Inkstand!" laughed Donald. "And the trees are the pens sticking in the top. Is that another inkstand over there?"

"No; that is the Sugar-Bowl."

"I didn't know sugar-bowls and inkstands looked so much alike," laughed Frank.

The guide was enjoying the fun with them. He drew the boat toward another island larger than the Inkstand which lay close to the above.

"What do you think we call this?" he asked.

"That looks something like a scow on the river."

"Good! It is called Steamboat Rock," said the guide. "Would you like to go into that cave?"

"Is there a cave here?" asked Donald.

"This is Lone Rock and there is the cave."

"Can we go into it?"

"We can go in now because the river is high."

He turned the boat into the entrance to the cave. The rock rose in an arch over their heads. Looking back through the entrance, they saw the river stirring in the sunlight, the red rocks and dark-green pine-trees of the opposite shore, and over all the bright blue sky. It looked like a picture set in a frame of sandstone.

"How dark it is in here!" said Donald. "I was never in a cave before."

"What made this cave, Uncle Robert?" asked Frank. "Did the water do it?"

"What do you think?"

"I think it must have been water but where did the water come from?"



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Steamboat Rock.



"Look overhead and tell me what you think about it."

"Oh, there's a creek," said Donald. "The water came down through it and started the cave."

"If there was carbon dioxide in the water it would eat out the lime," said Frank, thoughtfully. "Then the sand would be loose, and when the river rose it could wash the sand away."

"Perhaps so," said Uncle Robert, while the guide looked curiously from one to another.

"I believe water can do anything," said Frank.

"It certainly does a great many wonderful things," said Uncle Robert.

Then they rowed out upon the river again.

"Oh, see these rocks," said Donald, as they went farther on. "They look as though they had been all shaken up. Down below the layers are even, but up above they run every which way. At the top they are all loose and look as if they would tumble into the river any minute."

"That is called Ragged Point," said the guide.

"Well, it does look ragged," said Frank.

The river became very narrow. On each side the rocks banks were cut in great round scallops. In some places the pine trees grew densely to the edge of the scallops. It looked very wild and lonely. Not a sound broke the stillness but the dip of the oars in the water. It was with great difficulty that the boatman kept the boat in the middle of the stream.

"It is fortunate we didn't try it alone," said Uncle Robert.

"It doesn't seem possible that this is the same river we have rowed down all the way from Wausau," said Frank. "How narrow it is!"

"This is the narrowest place in the whole river," said the guide.

"How wide do you say it is, boys?" asked Uncle Robert.

"It isn't more than seventy-five feet," said Frank.

"Oh, not nearly so wide as that," said Donald. "About sixty, I say."

"Just fifty-two feet from bank to bank," said the guide, holding the oar firmly to keep the boat from turning around.

"There's an eddy here," said Frank, looking down into the dark water, which was very deep. "That's what turns the boat so."

"Yes," said the guide, "it is called Sexton's Eddy."

At one place the bank was very uneven. The big scallops were deep and regular.

"They look like boats drawn up at a landing," said Donald.

"Some one else thought that, too," said the guide. "That is the Navy-Yard."

"I never saw a Navy-Yard before," said Donald. "Those boats don't sail away very far, do they?"

"They are wearing away," said Frank.

Below the Narrows on the right bank of the river was a high pile of sand.

"That is the mouth of the old river," said the guide.

"What old river?" asked Frank.

"Did this river once flow in another channel?" asked Uncle Robert.

"Yes, it ran away over to the west of here."

"I wonder why it changed," said Frank.

"Let's not work any problems now, Frank,"



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Skylight Cave in the Navy-Yard.

said Donald. "There's too much to see here. Just see all the colors in that sand!"

"It's just so all the way along," said the guide.  
"You can find about any shade of red or yellow you want on any of these beaches."

"It would be interesting to see how many shades we could find," said Uncle Robert.

"Not long ago," said the guide, "I took a lady through The Dalles. She was some sort of a school-teacher, I believe, or some kin to one. Well, she wanted to stop at every sand-pile we came to to get some of the sand. She had a lot of little pill-bottles and she filled them and labeled them as carefully as if they were pills and she was afraid she'd take the wrong ones. For the life of me I couldn't think what a school-teacher could do with so many pill-bottles full of sand."

"Oh," said Donald, "I want to get some to take home to Susie. I wish I had some bottles."

"We can put it in papers," said Uncle Robert, "and then get it bottled when we get home. We shall have time to collect it to-morrow."

The water carried them swiftly down to what the guide called the Gates of The Dalles. The boys watched eagerly for every new point.

"Look at the great piece of rock standing out from the steep bank!" cried Donald, as the current swept them around a curve. "It looks like a big mouth open to swallow the first thing that comes along."

"That is the Hawk's Bill," said the guide.

Farther on Frank seized his camera.

"Wait!" he cried. "Please hold the boat still. I must have a picture of that ledge of rock while that man is sitting on it."

The guide drew the boat up so that they had a



good view of Visor Ledge, as he told them it was called, where a man sat on the very edge.

"I should think he would be afraid it would fall down with him," said Donald.

"Why didn't it wear down with the rest of the



Photograph by H. H. Bennett.

Visor Ledge.

bank, uncle?" asked Frank. "It's easy enough to see that the rest of the rock has been worn away."

"Can't you think of a reason why one layer of the rock would outlast the rest?" asked Uncle Robert.

"It must be harder," said Donald.

"Oh, of course," said Frank; "but I don't see what would make just one layer harder than all the rest."

When they reached the Gates of The Dalles Donald said:

"See, there is a village away up there on the hill."

"That is Kilbourn City," said the guide.

"Is that where we are to land?"

"We can't row much farther, for there is a dam just below."

"Oh," cried Donald, "there is a steamboat, a real steamboat!"

"Yes, there are several steamboats that go up and down the river here."

"I should think they would have a hard time going through the Narrows," said Frank.

"They do; sometimes they have to take out a big cable and pull themselves along."

"You may land us under that steep bank," said Uncle Robert to the guide. "I think we shall find a good place up there to camp. We are much obliged to you for rowing us down in safety."

"I'll see you again when you visit the Witches' Gulch," said the guide as he left them.

"We'll be up there in a day or two," called Uncle Robert after him.

They tied their boat under the steep bank and climbed up through a deep gulch to the higher ground. They found a nice place to camp under some fine trees where there was a beautiful view up and down the river. They carried up their baggage and pitched

their tent. Then they sat down under the pines to enjoy the view.

"I'd like to live here," said Donald, drawing a long breath of the sweet pine-scented air.

"Can't we stay here for a little while?" asked Frank.

"Yes, we'll stay here for a day or two. Then we'll take the cars and go home."

"And not go any farther down the river?" asked Frank. "I should like to go on down to the Mississippi."

"Oh, I wouldn't," said Donald. "It's been the best fun I ever had, but I—I know Susie wishes we would come back."

The next day they went to Witches' Gulch. They put the boat aboard the steamer and had it carried up. Then Uncle Robert rowed down, stopping at the beaches to get the sand for Susie. They found the Gulch very interesting. The rocks were carved in many strange shapes. In some places were big round hollows; in others only a creek separated the sharp ledges of rock. Planks and steps had been placed through the Gulch to make the walking easier. Through the bottom a little creek crept under the overhanging ledges or dashed foaming over the rocks in a little fall.

"Can it be possible, Uncle Robert, that that little creek down there cut all this rock away?" asked Frank.

"Can you think of anything else that might have done it?"



"No, I can't; but it seems so wonderful that just that little creek could have cut this rock into all these queer shapes."

"You must remember that this little creek carries very sharp tools to cut with."

The next day they went to Coldwater Cañon. The most interesting point to them was the Whirlpool Chamber.

"I'd like to be here when there is a great flood," said Frank, "and see the water rush through this cañon."

"How do you suppose this place became so round?" asked Uncle Robert.

Frank looked about until his eye fell on the outlet to the chamber filled with logs and sticks.

"See there!" he cried. "The outlet is dammed up. When a great flood of water rushes in here it can't get out fast enough, so it just whirls round and round. Then the sand and gravel in it cut away the rock."

"I think that must be the way of it," said Uncle Robert.

They followed Coldwater Cañon up to its source, which led them out of the cañon upon high ground.

"It isn't a very long creek," said Donald.

"It is making itself longer," said Uncle Robert.

"Let us go on a little farther."

"All the water from this land runs into Coldwater Cañon," said Frank as they walked along. "But see, how the land slopes the other way. From here the water must run into some other creek."



"Here is something that I especially want you to see," said Uncle Robert. "This high land is the water-parting which turns the water on this side into Coldwater Cañon and on the other into some other creek. Now, I told you that Coldwater Cañon is becoming longer. How is it doing it?"

The boys examined the land carefully.

"It seems to me," said Frank, "that the creek that makes Coldwater Cañon is wearing back at its source. If it does that, won't some of the water that runs into the other creek now flow into it after a while?"

"And in that way it steals water from the other creek," said Uncle Robert.

"It must be a wicked creek to steal from its neighbors," laughed Donald.

"But it is true. You know there are three ways in which a river cuts."

"It cuts straight down and out on both sides," said Frank.

"It cuts back at its source, too."

"Is it really true, uncle," said Frank, "that this river once flowed away up on top of these rocks?"

"Yes, and much higher probably."

"And the river alone cut all that rock away? Didn't the glacier help?"

"No; the river did it all."

"Well, I should like to know why the glacier didn't take all this sandstone away. It is ever so much softer than the Rib up at Wausau. It seems me that ice a thousand feet thick moving over

here would have ground it all into sand and carried it off."

"It surely would have done so had the glacier been here, but geologists tell us that no glacier ever passed over this part of Wisconsin."

"Did it go round here?"

"Why didn't it go over this land?"

"How can they tell?"

"Why or how it went around this place I do not know," said Uncle Robert. "This is called an unglaciated region, because no marks of glaciers are found here. Have you seen any?"

"I haven't seen any boulders; nothing but fine sand. But let's walk back to the tent. Perhaps we may find some."

They walked along the sandy road, but they saw no boulders; only red and yellow sand and sandstone rock.

"What made those queer-looking rocks with caps on?" said Donald on the way. "They look like big toadstools."

"The water did most of the work, but something else helped to make the rocks so round and smooth."

"It wasn't the glacier, because it wasn't here," said Donald.

"The glacier would have taken the whole thing away," said Frank. "Could the wind do it, Uncle Robert?"

"The wind could carry the tools with which to do it, just as the river carries its tools for cutting those steep banks."

"Oh, you mean the sand, don't you? I know it cuts. The other day the wind blew some sand against my face and it stung just like a lot of little needles."

"But why didn't the wind and the water take the caps off? And why are the pillars thinner in the middle than anywhere else?"

"If you would examine the caps you would find them harder than the rock below."

"Oh, just like Visor Ledge," said Frank.

"Yes; and these caps protect the rock just beneath them from being entirely worn away. The small place in the middle of the pillars is probably the softest rock."

After supper they sat under the pine-trees talking, while they watched the sunset.

"Did you see the swallows' holes in the bank as we came along?" asked Donald.

"I saw them," said Frank, "and I wondered how the holes were made."

"The swallows made them," said Uncle Robert.

"How could they make them in the rock? It is much harder than the bank along our river where there are so many swallows' holes."

"The sandstone is soft enough for them to pick out the holes with their sharp little bills. There is a great difference between the hardness of the rock here and up at Mosinee."

"How different everything looks, too!" said Donald. "Is that because of the difference in the rock?"

"That has much to do with it."



Photograph by H. H. Bennett.

Chimney Rock.



"What makes all the cracks in the rock that we see everywhere, Uncle Robert?" asked Frank.

"Do you mean the cracks that run up and down?" asked Donald.

"These cracks are joints," said Uncle Robert. "Most of them are vertical; that is what you mean by up and down. If this rock were made under the ocean, as we are told it was, how did it get to be dry land?"

"The ocean went away," said Donald.

"What made it go away?"

"Didn't you say the land rose?" asked Frank.

"Yes, the bottom of the ocean was lifted up above the water."

"I see," said Frank. "It cracked as it was lifted up."

"It may have been. In some rocks there are cracks made by the lifting up of the land. Joints are often formed by the cooling of the rock that has been heated. You remember what a thing does when it cools."

"It grows smaller," said Donald, quickly.

"Contracts," said Uncle Robert.

"It is the little joints that are not filled that let the water soak into the earth," said Frank.

"Have you noticed anything else about this rock?" asked Uncle Robert.

"There is one thing that has puzzled me ever since we came here," said Frank. "That is the way the strata run."

"I was wondering if we were to go home without your seeing that," said Uncle Robert, smiling.

"Why, we couldn't help seeing it," said Donald. "It is everywhere."

"In some places the strata slope about as much as our river-bank at home," said Frank. "Then these strata are cut off flat and others are piled on top as even as the bricks in a wall. At other places the even ones——"

"Horizontal," suggested Uncle Robert.

"Yes; the horizontal ones. In some places they are underneath and the sloping ones are on top."

"I saw a place in the Narrows," said Donald, "where the layers are thin and they run in three or four ways."

"I can't understand it at all," said Frank.

"It is not easy to understand," said Uncle Robert; "but the geologists have found a way to account for it. The sand that made this rock must have been deposited in shallow water where the currents are likely to change in many different ways. A current may deposit for some time, and then shift and flow from another direction. In that way the strata are not laid down evenly. So the irregular strata of this sandstone show how the currents deposited the sand. But I think it is time to turn in now and sleep. We have a great deal to do to-morrow."

"I'm sorry the trip is so nearly ended," said Frank; "I'd like to stay here a week longer at least."

The next day they took their boat below the dam and had their last trip on the river. They rowed down several miles between the sandstone walls and among many little islands. When they came back they

packed up their baggage and had the boat loaded on the freight-train to be sent home.

"Shall we start home this evening?" asked Uncle Robert.

"And travel all night?" asked Frank.

"Hurrah! We'll go in a sleeper," shouted Donald. "I was never in a sleeper. Let's go to-night, uncle."

"I feel as though we hadn't seen half there is to be seen," said Frank.

"Well, we will leave something for our next visit. Have you had a good time?"

"The best time I ever had," said Frank.

"It's been perfectly splendid," said Donald. "But I'm ready to go home now. I hope the thrashing isn't over. What time do we start, Uncle Robert?"

"Let's go to the station and find out," said Uncle Robert.

They did not have long to wait, and were soon rumbling away toward home.

## CHAPTER XIX

### HOME AGAIN

As the train drew up at the station the boys leaped to the platform. Susie ran to meet them, shouting:

"There they are! I see Frank. Hello, Donald! How d'you do, Uncle Robert? Oh, I'm so glad to see you!"

Susie danced up and down with delight.

"Father's here. We drove Nell down to meet you. Have you got all your things? Where's the boat? Oh, sure enough, you couldn't carry it. Did you have a good time? I'm so glad you've come home."

She led the way to the wagon, where Mr. Leonard sat holding Nell. After much talking they were ready to go. Uncle Robert sat on the front seat with Mr. Leonard; Frank and Donald with Susie between them on the back seat.

"How's mother, Susie?" asked Frank.

"And Barri?" added Donald.

"Oh, they're well. Everybody's well and everything's all right. But we've missed you dreadfully. I don't know what I'd have done if I hadn't been so busy."



"Busy!" laughed Donald. "What have you been busy about?"

"Well, I guess it would have kept you busy to feed the chickens and keep Barri from being lonely and gather the flowers and watch the thermometer and the barometer every day. I took the temperature in the morning for you, Frank, and in the evening for you, Don, so you wouldn't have empty places in your books. Of course, I kept up my own record, too. Uncle Robert, my book is almost full. Frank's record took a whole page, and so did Don's——"

"You shall have another book when that is full, Susie," said Uncle Robert. "It was good of you to keep the boys' records for them."

"I thought they'd like it," said Susie, with a beaming face.

"Did the thrashers come, Susie?" asked Frank.

"No; they were coming and it rained. Oh, you never saw such a rain as we had."

"That was when we were at Stevens Point," said Donald. "It was a regular flood on the river."

"It was here, too. I wish you could have seen the rain-gage. It ran over the top and down the outside. Father had to help me measure it. I have it all written down in my book."

"Did the river rise?" asked Frank.

"Oh, yes, but it didn't go over the cornfield as it does in the spring."

"You ought to have seen the Wisconsin," said Donald. "Frank took a picture of it."

"Maybe it won't be good," said Frank. "I'm

going to develop my pictures the first thing, and then you can see them all."

"I made some pictures, too," said Susie, "with the paints Uncle Robert gave me. I have them all for you to see."

"Oh, there's my calf!" cried Donald, as they crossed the bridge at the creek. "How he has grown! And there's Barri!"

"And mother!" cried Frank. "Hurry up, Nell. Hurrah, mother, here we are!"

Before the wagon stopped the boys were out, rushing to their mother, who stood on the veranda with her arms outstretched in welcome. Barri leaped about them with quick loud barks of delight. Uncle Robert sprang from the wagon, and as he lifted Susie down he gave her such a hugging as she hadn't had for many a day. Mr. Leonard drove away to the barn, looking over his shoulder at the happy group on the piazza.

"What loads of nasturtiums!" said Donald. "What did you do to make them blossom so, Susie?"

"Just picked them," said Susie. "The more you pick nasturtiums the better they bloom. But come to the barn, Don. I want to show you something."

"Is it nearly dinner time, mother?" asked Donald, as he started off with Susie. "I'm almost starved."

"I knew you would be hungry, dear, so I told Jane to have dinner early. It won't be long."

The mother, father, and Susie were eager to hear all about the wonderful trip on the river. So in the

evening after the work was all done they gathered upon the piazza, ready to listen. Uncle Robert was a good teacher, and wishing the boys to bring together all they had learned, he began:

"Now, boys, I want you to think a moment and then tell us all you can about the uses of a river—that is, what a river does for man."

"I can think of a great many things that a river does," said Donald.

"Well, you may begin."

"It is good to carry the logs down to the saw-mills," said Donald. "An old gentleman at Stevens Point told me how he used to drive logs down the river, as he called it. You know, father, all the land up there was covered with pine-trees. Now it's mostly stumps. The best tree is the cork-pine. In the winter the men go into the woods and cut the pines and draw the logs to the river with oxen and horses. They make a boom by pinning a lot of logs together from one side of the river to the other. The boom keeps the logs from going down too soon. They fill the water above the boom with logs, and when the spring floods come they open the boom and let the logs go. But they don't go all by themselves. It takes a lot of men with pikes to keep the logs moving."

"What is a pike?" asked Susie.

"A long pole with a sharp spike in the end of it. Sometimes the logs lodge on the sides of the river or are jammed on the rocks and in the rapids. Then the men have to go out and push them off. The old gentleman who told me about it says it is very dan-



gerous, but he liked it. I think I should like it, too. But they don't always drive the logs down this way. Sometimes they make big rafts. They bind the logs together in sections. Then they put a lot of these sections together and make one big raft. Sometimes they steer from behind with a big oar. When they come to the rapids they have to take the raft apart and float the sections down one at a time. Below the falls they put them together again and go on until they come to a sawmill. They used to float them clear out into the Mississippi. Then they would build a little house on the raft and live there. It must have been lots of fun!"

"They don't do that now," said Mr. Leonard.

"No; they have sawmills up there now. I wrote you about it. They have two kinds of saws."

"I remember," said Susie. "You wrote to me about the saws."

"They don't have much rafting on the river now," said Donald, "because they have the sawmills up there and bring the lumber down on the cars. It is cheaper and takes ever so much less time."

"You have told one of the great uses of a river, Donald," said Uncle Robert. "A great many rivers of the world have been and are still used for logging. You remember, Charlotte, how it used to be on the Merrimac, where we used to live. Every spring hundreds of men carrying great pikes would come along to drive the logs down the river. Can you tell another use, Donald?"



"Oh, to carry things up and down in boats," said Donald. "We didn't see much of that, excepting our own boat, but I know rivers are used for—for—what is that word, Uncle Robert?"

"Navigation," said Uncle Robert.

"Yes. That means a river is used to carry things from one place to another."

"In old times," said Mr. Leonard, "before there were any steamboats, they used to have great flat-boats to carry things up and down the rivers. On some large rivers they used boats with sails."

"But all that was changed when the steamboat came," said Uncle Robert.



A Mississippi steamboat.

"Who made the first steamboat, uncle?" asked Frank.

"Robert Fulton made the first steamboat to be

used for commerce. This was in 1807; but several years before that a man named John Fitch had driven a boat by steam."

"There were very large steamboats on the rivers before there were so many railroads," said Mr. Leonard. "On the Mississippi hundreds of steamboats ran from St. Paul to New Orleans. But the railroads changed all this."

"Navigation is surely one of the great uses of rivers. There is one continent that would have been

settled long ago if the rivers could have been navigated as the Mississippi can."

"Do you mean Africa?" asked Frank.

"Africa has rivers," said Mrs. Leonard. "There are the Congo, the Nile, the Zambesi—see how much I remember of my old geography?"

"But these rivers have rapids and steamboats can not go through them."

"There is a way of getting around rapids," said Mr. Leonard.

"Do you mean canals, father? We didn't see any canals, but I have seen pictures of them."

"Well, Donald, can you tell any other uses of a river?"

"Oh, yes; I know ever so many more."

"But it's my turn now," said Frank.

"All right, Frank."

"Rivers are used for manufacturing. Where there are rapids dams are built with canals and sluiceways. Then the water turns the big wheels like the one we saw at Wausau at the mill."

"Yes, rivers that run swiftly and have rapids are used for manufacturing. Manchester, Lawrence, and Lowell are manufacturing cities on the Merrimac."

"In a great many of these cities they use steam and electricity for manufacturing now," said Mr. Leonard.

"Yes," said Uncle Robert, "steam is more steady than water-power. Often the rivers are so low that there is not enough water to turn the wheels; but steam can be had at any time."

"I know another use for rivers," said Donald. "They carry seeds. All the way down the Wisconsin on the islands and flood plains there are elm-trees and bushes. The river carried the seeds and dropped them and they grew."

"A river makes land," said Frank.

"Makes land!" said Mrs. Leonard. "Please tell us how that is done."

"Why, mother, you know that our cornfield down there is a flood plain. It was made by the river."

"Uncle Robert told me that the day we had our picnic on the island," said Susie. "I remember."

"But tell us how it is done, Frank," said Mrs. Leonard.

"All right, mother. I'll begin at the beginning. You see every river has a basin; which means all the land drained by the river and its tributaries."

Here Frank took his pencil and drew a river-basin.

"Now this," he said, "is all the land drained by the river and its tributaries. The river drains this land, because the land slopes toward it. I don't mean that all the land slopes toward the main river; it may slope another way, and still slope toward a tributary of the river. But some of the land slopes toward the river. This line up here is the water-parting. It is the line from which the water begins to flow toward this river. On the other side of this line the water goes into some other river. It belongs to another river-basin. After the big rain at Stevens Point we saw just how a water-parting is by the way



the water ran off the road. Uncle Robert says the water-parting is always changing just as the river is always changing its bed."

"We saw a creek at The Dalles," said Donald, "that was cutting back at the source and stealing water from another river-basin."

"And that changed the water-parting," said Frank. "All the water that falls in the river-basin, if it isn't used in some other way, flows down into this river. Each tributary has its own basin and drains the land that slopes toward it, and they all are in the main river-basin."

"Why don't you just say the water flows from the water-parting to the river?"

"Why, Donald, you know that isn't so. Most of it sinks down into the earth and percolates through the soil. When it reaches some place where it can come out of the ground there is a spring."

"Like our spring?" asked Susie.

"Yes. I can tell you about that, too. But now I want to tell you what a river does. I forgot to say that there are two slopes in a river-basin, and these slopes meet here," pointing with the pencil.

"At their lower edges," said Uncle Robert.

"And that's where the river flows," said Donald.

"The line of meeting of the two slopes is where the river flows," said Uncle Robert.

"Yes, this is the river-bed. There are two banks to a river; the one on the right side going down the river is the right bank, and the other is the left bank. The bed and the two banks made the channel of the



river, and as the water runs through the channel it cuts down into the earth."

"It cuts into the rock, too," said Donald. "We saw it at The Dalles."

"Well, I mean rock or anything when I say earth. Of course there is the solid rock, like the gneiss and sandstone, but the gravel and sand are just loose rock. Now if a river ran straight down until it was so low it couldn't flow any more, it would have straight high walls like a cañon. But a river never flows straight; it curves and curves all the way from the source to the mouth. The water doesn't flow just the same all over a river. It always flows faster in one place."

"It is faster on Mr. Davis's side than on ours," said Susie.

"That is the deepest part of the river, too," said Donald.

"Yes, the deepest and swiftest part of a river is the current. The swiftness of the current depends upon the slope of the bed."

"The current is almost always at one side of the river," said Donald. "Sometimes it is in the middle."

"That is when the channel is nearly straight," said Frank. "But the current changes; that is what makes the river wind. It flows along a curve to the end; then it shoots across to the other side of the river. There it cuts into the bank and makes a curve, and that throws it back to the other side, and so on all the way down the river."

"It doesn't curve much at Mosinee," said Donald.

"That is because it has much hard rock to cut through. Uncle Robert told us that the softer the land is the more the river winds. It certainly did wind a great deal more through the sand country before we came to The Dalles."

"Sometimes there is a big bend in the river when it comes against some hard rock. Don't you remember Stevens Point?"



Meanders of Trout Creek, Yellowstone Park.

"Good for you, Donald," said Uncle Robert. "I'm glad you didn't forget that."

"I don't see how the boys remember so much."

"Why, we saw it, mother. That's the way we remember. When you see a thing you can't forget it," said Frank.

"Can you tell us more about the current, Frank?" asked Uncle Robert.

"I said that the current flows from side to side,

crossing at the end of the curve, didn't I? Well, where the curve goes into the land the deepest is the place where the current strikes, so of course that is the place it cuts the most. The deeper the curve the quicker the current is thrown across the river. Where the curve is not deep the current goes straight on down the river."

"Then the curve is changing all the time," said Mr. Leonard, who was watching the drawing closely.

"Yes, the curve works up the river. If it didn't, the river would be perfectly straight after a while. Instead of that it curves more and more. Uncle Robert calls the bank where the current is cutting the concave bank. It is generally high and steep. Opposite the concave bank is the convex curve. This land generally is low and flat."

"The floods cover it and leave a lot of earth," said Donald, "and after each flood it is a little higher. It is building up as long as the floods cover it."

"On the concave side the water is very swift, because that is where the current is and it digs deeper and deeper and cuts away the bank as if it were trying to make the river wider. But the deeper it digs down on that side the lower the surface of the river is."

"I don't understand that," said Mr. Leonard.

"Why, it is this way. The bed of the river is not level. It is deepest under the current."

"I see that," said Mr. Leonard.

"Well, the deeper the bed is, the more the surface of the water—I mean the whole river—will sink down. Isn't that so, father?"



"Yes, I see now," said Mr. Leonard.

"And the deeper the bed sinks down the higher the land will become on the other, or the concave side," said Mrs. Leonard. "Suppose the water on that side is ten inches deep and the current digs down deep enough to hold all that water; then the place where the water was on the concave side would be dry land."

"Hurrah for you, mother!" cried Donald. "You are almost as good at working problems as Frank is."

"Of course the deeper the channel becomes, the higher the bank will be on the curved side," continued Frank. "Then at the same time the current is cutting into the bank, too. What does that do to the river?"

"It takes more of the water over to that side," said Mr. Leonard.

"And if the water goes over to the concave side, what happens to the other?"

"There's only a little water left there," said Susie. "I can see that."

"And the shores become higher," said Mrs. Leonard. "The land wouldn't really be any higher, but the river would sink down so the shores would look higher."

"Now don't you see that a river is always cutting down into the ground and cutting into the bank on one side or the other? It took me a long time to work it out, but now I shall never forget it."

"That is very plain now, Frank, but you were going to tell us how the river makes land."



"I've just come to that," said Frank.

The clock struck nine.

"So late?" said Mrs. Leonard. "It is very interesting, but we'd better hear the rest another time."

"Do you understand all that?" whispered Susie to Donald as they went up-stairs.

"Of course I do," said Donald. "You just wait until you hear some of my stories. But doesn't Frank know a lot? He never had much to say in school. Good night, Susie. I'm glad we're home again."

"So am I," said Susie.

## CHAPTER XX

### THE USES OF A RIVER

ANOTHER day's work was done. The time had come when they could sit together and talk over what the boys had seen on the river.

"It is too cool to sit on the piazza to-night," said Mrs. Leonard. "We'd better stay indoors."

"Now, Frank," said Uncle Robert when all was ready, "tell us how the river makes land for the farmer."

"You remember how the river cuts down and swings from side to side?" began Frank.

"You ought to be a school-teacher, Frank," said Susie. "You talk just like one."

"If I were, I'd keep you after school for making fun of me," said Frank. "Now, Susie, you tell what becomes of all the earth the river digs out of its banks and its bed."

"I don't know," said Susie.

"I do," said Donald. "The river carries it away down to the sea."

"I don't see how the river can carry earth," said Susie.

"Don't you know how muddy it looks when there's a flood?"

"Oh, yes," said Susie. "Is it the earth in the water that makes it look that way?"

"It's the earth," said Donald. "It is all mixed up with the water and is carried along for miles and miles."

"But it takes a long time for it to reach the ocean," said Frank. "When the water is swift it can carry a great load of earth, but when it slows up the earth is dropped and makes flood plains and islands. Then after a while the current changes or something happens to send it on down the river again. Uncle Robert says that sometimes even the swift currents get a bigger load than they can carry, and they have to drop some of it to the bottom. When a river flows into a lake it drops the earth it has been carrying right at its mouth. That is because the water in the lake is still. You know if you have some muddy water in a pail and let it stand, the dirt settles to the bottom. That is how it is in a lake."

"It makes islands at the mouth of the river," said Donald.

"I thought the land made by a river at its mouth was called a delta," said Mrs. Leonard.

"It's just the same," said Donald. "We saw ever so many as we came down in the boat, where tributaries flowed into the river. You see each tributary brings down earth and drops it at its mouth. That makes an island and the tributary has to divide and flow into the river on both sides."

"I see," said Mrs. Leonard.

"When the water is as clear as our river is now, it doesn't carry any dirt—earth," said Susie.

"Yes, it does," said Donald. "You tell about that, Frank. I don't understand it very well."

"Why, it's just this way," said Frank. "There's the earth all mixed up with the water, that we can see, and then the river carries a great deal in solution that we can't see."

"How do you know?" asked Susie. "What does that word mean?"

"If you put some sugar in a glass of water, what does the sugar do?"

"It dissolves. You can see it."

"How do you know it is there?"

"Because the water tastes sweet."

"What if I put some salt in the water?"

"That would dissolve, too."

"But the salt would still be in the water, wouldn't it?"

"Oh, yes, but it wouldn't taste good at all."

"Well," said Frank, "the water dissolves the sugar and the salt and they are in the water just the same, but they are in solution."

"But there isn't any sugar or salt in the ground for the water to dissolve."

"There is a great deal of salt; Uncle Robert says so. I don't know about the sugar. But let's not stop to talk about the material the river carries in solution now. I want to tell you how the river makes land. A river is a great grist-mill and it grinds up rocks for



grist. What is the land called that the river flows over, Susie?"

"The bed."

"The bed of the river is covered by gravel and sand and mud."

"Sometimes there are big boulders, too," said Donald. "We waded out into the river, and in some places it was all sand. In others there were gravel and boulders and sharp stones."

"This is the material that moves down the river," said Frank. "The force of the water keeps turning it over and over, and as they turn, the boulders and sand and gravel rub against each other and grind each other up. The water doesn't grind, Uncle Robert says. It is just the force that moves the things that do the grinding."

"So that is how a river is a mill, is it?" asked Mrs. Leonard. "It grinds up rock."

"There is more to it yet, mother. Under this material that is always moving down the river is the hard bed; sometimes it is solid rock. As the gravel and sand and stones roll over and over they grind down the bed of the river, too. What do you call it, Uncle Robert, where the rocks rub against each other and are ground up?"

"Corrosion," said Uncle Robert.

"My, what a big word!" said Susie.

"It takes big words to tell all the work a river does," said Donald.

"Now you remember I told you about the current cutting into the banks. It cuts and cuts, and after

a while the bank above the water tumbles down and is carried away."

"That's just the way Mr. Davis's bank does," said Susie.

"We saw a place on Mrs. Lilly's farm," said Donald, "where the current is digging into the bank. She told us that twenty feet had been worn away in forty years."

"And all this earth from all the banks and from the bed is carried down by the river. Then all the tributaries bring loads of earth into the main river. You know I told you that every tributary has a basin and a valley of its own."

"Is our creek a tributary to our river?" asked Susie.

"Yes, and we know that the creek carries down lots of earth," said Donald. "We can see it in the spring."

"But these are not all the ways a river has to get earth," said Frank. "The rain beats on the ground and washes off a great deal of earth. It takes some from every part of the basin. If the ground is bare it washes more. Where there is grass the roots hold the soil and it can't wash so much, and where there are trees the rain strikes the leaves and doesn't have a chance to carry away the soil. Then you know some kinds of soil are more easily washed away than others."

"I should think there wouldn't be any ground left," said Susie.

"But you haven't told us how the river gets what

it carries in solution," said Mrs. Leonard. "I want to hear about that."

"You see when it rains some of the water runs off into the creeks and the rivers. But a great deal of it sinks down into the earth. The earth is full of little holes. What did you call the holes in the ground and the rock, Uncle Robert?"

"Interstices."

"Oh, dear," said Susie. "I could never say that."

"It is porous, too," said Donald.

"The water sinks down into the ground and comes out in springs."

"I know how a spring is made," said Donald.

"You shall tell about it by and by," said Mr. Leonard. "Now I want to hear what Frank says about solution."

"I can't tell it as well as Uncle Robert can," said Frank. "I don't quite understand it."

"Try," said Uncle Robert.

"Well, in all the rain-water there are acids. Is that right, Uncle Robert? When the water gets into the ground it finds minerals that the acids dissolve. Limestone is one. It is dissolved just as sugar and salt are, and the water carries it away. Then it comes out in springs and flows into the creeks and rivers."

"So that is what makes mineral springs, is it?" asked Mrs. Leonard.

"Yes," said Uncle Robert. "Mineral springs are made by the water percolating through rock that contains salt, sulphur, iron, and such things. They



are soluble in water, especially when the water contains acids. Frank could have told you of other things in the water that dissolve the minerals in the earth."

"Why doesn't all the earth dissolve?" asked Susie.

"It is always slowly dissolving, but at the same time it is as rapidly coming out of solution, as the water gives back to the earth at some point the material it takes from another."

"We saw a quarry at Stevens Point," said Donald, "where we could see how it had been working. Frank has a picture of it."

"Here it is," said Frank, taking it from some he had printed that day.

"Oh, see," cried Susie, "how the rock is all cracked and broken on top! Down at the bottom it is like a solid wall."

"The dissolving agents in the water broke it up that way," said Frank. "You see the water falls on top of the hill and soaks down into the ground. These cracks that go up and down are joints, and they let the water run down into the rock. Then it runs between the layers or strata, and the lime is dissolved and leaves the sand."

"We saw a man lift a layer of rock," said Donald, "and there was fine sand under it. The water had dissolved the lime and left the sand."

"Did the water take the lime into the river?" asked Susie.

"I don't know," said Frank; "but wherever the water went the lime went with it. Now you see that



the whole basin, the surface and the ground under the surface, gives something to the river. A great deal is dissolved and a great deal is not dissolved. The river takes it all away, and makes flood plains out of it. You see while the river is cutting into the bank on the concave side it is building on the convex side."

"Our cornfield was made that way," said Donald.

"Tell me just how it was done," said Mr. Leonard.

"I told you last night how the river wears its bed deeper on the side where the current is. That makes the other side higher. At first the water is shallow and it flows more slowly than it does where the current is."

"And where the water is slow the earth drops to the bottom," said Donald.

"That builds up the bed on the convex side," said Frank, "at the same time that it cuts it down on the concave side. Then by and by it isn't river-bed any more. All the water has moved over to the other side."

"It is a beach, then," said Donald, "and it slopes toward the river. Here is a picture of one."

"But when the spring floods come, the water spreads all over the beach. You know in a flood the river carries more earth than at any other time. So as the water flows slowly over the beach, it drops the earth and the beach is built up higher and higher every spring. Then it is a flood plain."

"The queer thing about a flood plain is that it slopes away from the river toward the old bank," said Donald.

"I thought you said a beach slopes toward the river," said Mr. Leonard.

"It does," said Frank, "but a flood plain slopes the other way. When the river spreads out it slows up. That makes it drop its load and the most of the



Flood-plain of the James River, Va.

earth is dropped close to the river. This goes on ever so many years until the flood plain is higher by the river than it is by the old bank."

"What do you mean by the old bank?" asked Mrs. Leonard.

"Why, the bank where the river flowed before there was a beach. Our bank is the old bank here,

mother, and you know when the river begins to rise it runs around by our bank before it covers the cornfield."

"That's a fact," said Mr. Leonard. "One flood we had, I thought there would be a channel cut through there, but there wasn't."

"Then the cornfield would have been an island," said Donald. "We saw an island at Wausau that had been made just that way."

"The river makes flood plains all the way from its source to its mouth, and Uncle Robert says some of them are very wide."

"There is one on the Mississippi that is forty-two miles wide," said Uncle Robert. "Professor Shaler tells us that one-fifth of all the people in the world live on flood plains."

"I should think they'd get wet when there is a flood," said Susie.

"Oh, you see, after a while the flood plains become so high that they aren't flood plains any more," said Frank.

"I don't see how that is," said Mrs. Leonard.

"Why, you see, mother, that all the time the floods are bringing down earth and making the flood plains higher the current is cutting the bed deeper on the other side."

"Oh, yes, that lowers the river, and so makes the land higher."

"But there is something more about a flood plain that I want to tell you," said Frank, his face glowing with interest. "The river is all the time changing



its curves. We had a good chance to see how it was on Mrs. Lilly's farm, but it took us a long while to work it out. Back of her farm is a great deep curved bank that was made by the river. Then the current left that side and a flood plain was built. It is so high now that Mrs. Lilly says the water hasn't covered it since she has lived there. Then the current came back to that side and cut a curve in its old flood plain. I can show you how it is in this picture that I took. Here is the old bank; this is the first flood plain, and this low bank is where it cut into the flood plain. Then the river swung away again and built another flood plain, and now the current is back there cutting it away. This land above the second bank Uncle Robert called a terrace. He said some rivers have a great many terraces, and some of them are miles wide."

"What about the bank back of our farm?" asked Mrs. Leonard. "I wonder if we live on a terrace."

"I think we do," said Uncle Robert.

"Well, well, mother," said Mr. Leonard, "to think that we should live here all these years and just find that out! We're rather old pupils, but it seems that we can learn something yet."

"Do you know why the flood plain is the best land for a farm," said Frank.

"Father told us that long ago," said Susie. "It is because the river keeps it watered all the time."

"Yes, but there are other reasons," said Frank. "It is because the river brings new material down and spreads it over the flood plain in the time of high water."



"Frank is right," said Uncle Robert. "Every square inch of earth above the flood plain gives something to make it richer."

"And the river mixes all these materials together; clay, sand, loam——"

"Vegetable mold," said Uncle Robert.

"There isn't anything left out," said Frank, "and after the river has mixed all these different kinds of earth together, it spreads them out on the flood plain, on our cornfield, father, and on all the flood plains."

"It's no wonder that I don't have to fertilize my cornfield," said Mr. Leonard. "It is done every spring for me."

"Well, I have another question," said Mr. Leonard. "Where does the material in solution go? Does any of it stop on my cornfield?"

"Oh, yes, some of it does, but a great deal of it goes into the ocean and helps make new rock. I can't tell about that unless Uncle Robert helps me."

"Let's keep that for another time," said Uncle Robert. "I am thinking now of another use of a river which we have not talked about. You have told how the river makes flood plains and terraces. The terraces we saw were made in an old flood plain—cut out of land made by the river itself. Often rivers cut their paths through solid rock in the form of terraces, and all the terraces with the flood plains make up the river-valley, made by the river itself."

"But that doesn't mean the basin," said Frank. "There is a great deal of land in the basin outside of valley."

"That is true; but in some places rivers cut the whole width of their basins into valleys, especially near the mouths. Now, can you guess what this other use is?"

"The river makes its valley."

"And what is the use of the valleys?"

"In the valleys we find the best land."

"Yes, and something more."

They all sat thinking.

"We must look to history to find out this use of a river-valley. I will tell you a little about it now. Then later you can study further for yourselves."

Uncle Robert took up a book and opened it to a map.

"The river-valleys are the great highways by which people have been able to go from place to place and from one country to another," he said. "On this map is Asia, and in this part of the country," pointing to it, "there lived, many years ago, a very warlike and barbarous people called Huns. They wished to conquer other countries, so they marched west until they found the mouth of a great river emptying into the Black Sea. Here it is. See if you can find where it rises, Donald."

Donald traced the river with his finger to its source.

"Away over here," he said.

"Yes," said Uncle Robert. "It has cut a valley almost through Europe. Up this valley the great army of the Huns poured into Europe, conquering as

they went. Some day you will learn another great use of mountains. Always when people have become less warlike and have wished to settle down in farms, villages, and cities, they have had to defend themselves from their enemies. Where there were mountains all around them, as in Switzerland and Greece, can you see what the mountains would do for them?"

"Their enemies couldn't get at them."

"They might get at them, but they would have a great deal of trouble doing so because of the mountains which they would have to cross."

"Unless there were river-valleys," said Frank.

"Yes. You can see how the river-valleys have been the pathways by which people have gone from one country to another. They could go up the valleys because the land is lower and smoother. Many rivers have been used in this way."

"I think the valleys are used in much the same way now," said Mr. Leonard.

"How, father?" asked Donald.

"Where are the railroads built?"

"In the valleys of the rivers," said Donald.

"Yes, this is largely true. In the Rocky Mountains the railroads generally follow the streams. For example, there is the Platte. For miles and miles the railroad follows the windings of the river, up to the Great Divide."

"What is the Great Divide?" asked Frank.

"It is the water-parting. The water that falls east of the Great Divide flows to the Pacific Ocean.

That which falls on the other side flows to the Gulf of Mexico."

"The water in our creek goes down to the Gulf of Mexico, doesn't it?" said Donald.

"Yes," said Uncle Robert, "if nothing happens to it on the way."



## CHAPTER XXI

### UNDERGROUND WATER

"WELL, Frank," said Uncle Robert, "have you told us all you can about the river?"

They were sitting on the piazza after an early supper, watching the setting sun.

"I could never tell half that you told us, Uncle Robert," said Frank. "I can't remember it all. And I don't believe anybody ever could learn all there is to know about a river."

"To be sure not," said Uncle Robert. "The beautiful thing about studying the Big Book is that there is always something more to learn."

"Can't you think of anything more to tell us?" asked Mrs. Leonard. "It is all very interesting."

"Uncle Robert asked us one question that was a good one. We had to think a long time before we could even begin to answer it."

"What was the question?" asked Mr. Leonard.

"Where does the river get all the water?"

"From the rain, of course," said Susie. "I can answer that right off."

"That's what we said," replied Frank. "Then Uncle Robert said, 'Suppose it doesn't rain for a very long time?'"

"Then the river would stop," said Susie.

"But our river never stops. Sometimes it is very low, to be sure, but it keeps on flowing. You remember at the time of the big drought, when the wells went dry, there was water in the river. Where did it come from?"

"Perhaps it rained where the river comes from," said Susie.

"No, it didn't. There wasn't any rain in the whole basin, up above or down below."

"Maybe there is a lake to supply the river," said Mrs. Leonard.

"Uncle Robert told us there is one on the Wisconsin," said Donald.

"Then the tributaries help," said Mr. Leonard.

"Yes, Uncle Robert says all these things help the river," said Frank; "but you haven't guessed it yet. Shall I tell?"

"Oh, yes, Frank, please do," said Susie. "I don't like guessing games."

"The lakes and the snow are reservoirs to feed the river," said Frank, "but the greatest reservoir of all is the ground. I told you how some of the rain that falls on the surface soaks into the ground."

"It percolates through the little interstices," said Donald, who liked to show Susie how much he knew.

"How far down does it go?" asked Susie. "Right through the earth?"

"It goes until it stops," laughed Donald.

"Never mind Donald, Susie," said Frank; "I'll

tell you how it is. All kinds of earth and rock, too, no matter how hard it is, take up water. But there are some rocks and earth in which the holes or interstices are so small that they fill up and the water can't go any farther."

"What do you say of the ground when water can't go through it, Donald?" asked Uncle Robert.

"Let me think," said Donald. "Why, it is impermeable. Is that it?"

Uncle Robert nodded, smiling.

"The ground is made in layers or strata."

"A great deal of it is, Frank," interrupted Uncle Robert, "but not all."

"The rain soaks through the ground until it comes to an impermeable stratum," said Frank. "It may be clay, or it may be some kind of rock. It can't go through this stratum, you know, because it is impermeable, so it runs along on top of it."

"Wait!" cried Donald. "I was to tell about that."

"Well, go ahead."

"Then, somehow this hard strata—stratum," said Donald, "comes out of the ground as the limestone does in our hill. Then what would there be, Susie?"

"I don't know. Can you draw it for me?"

"Of course, I can. Please, let me take your pencil, Frank? This is the ground, and this is the impermeable stratum," said Donald, drawing. "Here it comes out of the ground and the water is on top of it."

"Then the water comes out, too," said Susie.

"What does that make?"

"Oh, a spring!" cried Susie. "Why, that is just how our spring is."

"That is how springs are made," said Donald, handing the pencil back to Frank.

"Sometimes these hard strata are quite level," said Frank, "and sometimes they dip."

"What do you mean by dip?" asked Mrs. Leonard.

"That means the slope of the strata," said Frank. "Sometimes they slope a great deal and sometimes only a little. Now the earth above the hard strata holds the water and lets it drain off slowly. If there is a great deal of rain, the earth fills to the very top."

"Or is saturated," said Uncle Robert.

"So when we dig a well we dig down into the earth that holds the water," said Mr. Leonard.

"You know, father, how the water in our wells rises and falls. If the weather is very dry it falls, and if there is a great deal of rain the water rises in the wells. Now, Uncle Robert says that there is a level to the water in the ground just as there is to the water in the river, and it rises and falls just as the river does. It may be down ten or twenty feet, or even lower. In some places it comes to the surface and stays there."

"That makes a swamp," said Donald.

"It wouldn't be good to have it come to the surface everywhere, would it?" said Mrs. Leonard.

"The wells would be full then," said Susie.

"What is an artesian well?" asked Mrs. Leonard.

"This is the way I understand it," said Frank. "There are cracks and joints in all the rocks. We saw



them up at The Dalles. You can see what the water would do when it came to these joints."

"It would go right down into them," said Susie.

"Sometimes they are very deep," said Frank, "and then there may be other openings below where the water can go down. So Uncle Robert says the water goes thousands of feet into the earth. Now I will show you what an artesian well is."

Frank took up his pencil and began to draw. "This is the sandstone at Stevens Point," he said. "This sandstone runs away down under the ground all the way from Stevens Point to Chicago, maybe farther. In Chicago they bore down over a thousand feet. I think it is twelve or thirteen hundred, but I don't remember exactly; and there they find this same sandstone. There is water in it that has percolated all the way down, and when they strike the sandstone the water bursts right up into the air. There is a picture in 'Harold's Explorations' that shows how it works."

"That is owing to the pressure," said Mr. Leonard.

"That is an artesian well," said Frank. "But there is one thing I don't understand. I asked Uncle Robert, but he didn't tell me, and I'm sure I can't work it out. It's the water that soaks down into the soil that feeds the plants. Of course if there were no water there would be no plants. Trees couldn't grow without a great deal of water. Just think how the sap runs out of the maple-trees when we tap them in the spring. That is because they take up so much water."

"Sap isn't water," said Susie.

"What is it?"

"Why it's—it's just sap."

"If you should put some sugar in a tumbler of water, would it be water?"

"Oh, yes, it would be sweetened water. Is sap just sweetened water? Where does the sugar come from?"

"The sap of an oak-tree is bitter," said Uncle Robert. "Where does the bitter come from?"

"I never thought about that," said Frank. "But I know the trees couldn't grow at all if it were not for the water in the ground."

"But the water itself doesn't make the trees grow," said Uncle Robert.

"They would die if there were no water," said Frank, "so there must be something in the water to make them grow."

"And where does that something come from?" asked Uncle Robert.

"It must come from the ground."

"But how does it get into the tree?"

"It goes up the roots," said Donald.

"But what is it that goes up the roots? The tiniest grain of sand couldn't go up the root of a plant."

"Oh, I see," cried Frank. "The water dissolves something in the earth and the trees take it up in solution."

"I'd like to know how it goes up a great high tree," said Susie.

"That is one of the most wonderful things there is to study, Susie," said Uncle Robert, "and we may never understand how it is done. But we are told that the sun is the power which draws the water from the ground up into the plants and changes the minerals that are dissolved in it into wood and leaf."

"Oh, I remember you told us that before," said Donald.

"But what puzzles me," said Frank, "is how in the world the water reaches the roots when the level of the ground-water is away below the surface."

"The trees must send roots down to the water," said Donald. "You know Uncle Robert told us about the long roots some plants have in very dry countries. He said they send the roots down to find the water."

"But how do plants know where the water is? They can't think."

"They act as though they could sometimes," said Uncle Robert. "But that doesn't answer Frank's question. The trees and plants grow, even when the roots do not go down to the level of the ground-water."

"It is a curious question," said Mr. Leonard. "I never thought of it before. And the level of the ground-water must change, for I know it does in the wells."

"And when it is very dry, the grass is like hay," said Susie, "and the leaves in the garden wilt."

"Let us go into the house and make some experiments," said Uncle Robert. "Susie, can you light the lamp?"

As Susie touched the wick with the match, Uncle Robert said:

"And here is a problem right before us. What is it that burns?"

"The oil."

"But the oil is in the lamp. How does it get to the light?"

"It goes up the wick."

"How does it go up the wick?"

"Why, it soaks up."

"But water and all fluids run down. How can the oil in the lamp run up?"

"Well, I declare, I never thought about it before," said Donald, shaking his head.

"Will you get a tumbler about half full of water, Donald?" asked Uncle Robert. "And, Susie, can you find a piece of string or cloth? A strip of old linen is best."

When they returned Uncle Robert said:

"Now, Susie, put one end of the cloth in the water."

"Oh, see," cried Susie, "the rag is getting wet all the way up."

"The water is just climbing up it," said Donald.

"Let the end hang over the edge of the tumbler," said Uncle Robert.

Susie did so, and they watched it until the water began to drop from the end of the cloth to the table.

"The water has climbed up the side of the glass and over the top," said Donald. "How long will it do that, Uncle Robert?"



"Until the glass is empty, if we leave it long enough," was the reply.

"Well, I should think when the lamp isn't lighted the oil would go up the wick and then run over," said Frank; "but it doesn't. The oil fills the wick and the rest stays in the lamp."

"If the wick hung over the side of the lamp it would do as the water does," said Uncle Robert.

"When the lamp is lighted a great deal more oil must go up than when it isn't," said Frank.

"There must be some reason for that," said Uncle Robert.

"The light," said Susie.

"Or rather the heat," said Uncle Robert. "Now, when it is hot and the wind blows, how does the ground in the plowed fields or garden change?"

"It becomes very dry."

"What makes it dry?"

"The wind and the heat."

"If you dig down just a little way into the earth what do you find?"

"Moist earth, unless there has been a long drought."

"What keeps it moist down below the surface? The level of the ground-water may be many feet below that."

"Do you mean, Uncle Robert," asked Frank, "that the water in the ground climbs up to the surface just as the oil does in the wick and the water in the string?"

"Just the same way, Frank. I can't explain it

to you, for I don't understand it myself, but the fact is certain. The water moves up through the interstices in the soil, and the hotter it is on the surface the more water moves up."

"Then water doesn't always go down."

"In this case it does not; it moves up to the surface. This is called capillary attraction. A tube so fine that only a hair could go through it is called a capillary tube. If one end of this tube is placed in water, the water will rise in it higher than it stands around the tube. So solid substances like the lampwick and the soil have fine hairlike interstices through which liquids such as water and oil can rise."

"Is it the roots of the plants that draw the water up?" asked Donald.

"No, the soil itself draws the water until it comes within reach of the roots. As I have said, if the surface is hot and dry, more moisture is drawn up from below. And with it comes the earth that it has dissolved, which feeds the plants."

"Do all plants feed on the same kind of food?" asked Donald.

"Oh, no; different plants need different foods."

"That is why I change the crops about from field to field each year," said Mr. Leonard. "If I planted them in the same field all the time there wouldn't be enough of the particular food each one needs to make it grow."

"It is wonderful," said Mrs. Leonard, "that each plant should know what to take up."

"What do the plants do where it doesn't rain at all?" asked Frank.

"There are deserts and nothing grows there," said Donald.

"But there are oases in deserts," said Mr. Leonard. "How does the water get there?"

"I think it comes through the ground from some place where it does rain," said Uncle Robert. "It may travel many miles underground before it comes to the surface as Frank explained in the case of the artesian well."

"A great deal of desert land is being changed into splendid farms in these days," said Mr. Leonard.

"Yes, by irrigation. We must study irrigation. It shows a very interesting use of a river-valley."

"So it is the water in the ground that keeps the river supplied, is it?" said Mr. Leonard.

"Yes," said Frank; "and as it soaks down into the ground and moves over the impenetrable strata it does a great deal of good to everything that grows."

"When the water has run right up through a tree, where does it go then?" asked Susie.

"Don't you remember? It comes out through the leaves."

"And then where does it go?"

"Into the air?"

"It is vapor then," said Donald, "so we can't see it."

"The water falls on the ground in rain," said Uncle Robert, "soaks into the earth, does its work, feeds all

the little roots, and then it comes out in springs, fills the brooks and creeks, and flows down the rivers into the sea."

"Then it comes back again," said Donald. "Uncle Robert told us about that one day. The heat of the sun evaporates the water, the wind brings it back in clouds, and it falls to the ground again."

"How interesting it all is!" said Mrs. Leonard.

"There is one question I want to ask before we go to bed," said Mr. Leonard. "While I was working in the field to-day I was thinking it all over—all that the boys have told us of the work of a river. Frank made it very plain how the river builds land all the way from its source to its mouth, and how the deltas are formed at the mouths of rivers. I have read about the deltas of the Mississippi, the Ganges, and the Po, but some rivers quite as great as they are have no deltas. There is no delta at the mouth of the Amazon. Now, boys, you have answered a great many hard questions, can you tell why that is? I'm sure I don't know, for I have never seen it."

"We saw it up the river. A tributary brings down earth, and if there is no current where it flows into the big river, it drops the earth right there and makes a delta. But if the current of the big river flows on that side it takes the earth and carries it down the river as fast as the tributary brings it in. Then there is no delta."

"But that doesn't explain how it is in the ocean."

"I think I shall have to answer that," said Uncle Robert. "There are great currents in the ocean that



move like strong, mighty rivers. When these ocean currents come close to the mouths of the rivers, they take away all the earth the rivers bring down. The fresh water of the Amazon is carried a hundred miles or more out into the ocean. Every day it carries down enough earth to make a farm ten times the size of this, but the current in the ocean sweeps it all away. That is why some rivers that flow into the ocean have no deltas."

"The Nile has a great delta," said Mrs. Leonard.

"Yes, all the rivers that flow into the Mediterranean have deltas. But there are no ocean currents in the Mediterranean."

"How I would like to see with my own eyes these places that we read about," said Mrs. Leonard.

"Yes," said Frank, with the air of an experienced traveler, "Don and I enjoyed our travels very much."

"But I've found nearly everything right here," said Donald, "that we saw on the Wisconsin."

"I've been making a sketch of the farm," said Frank, bringing out his drawing-book.

"How much better it is done than the first one you made," said Mrs. Leonard.

"That shows what practise will do," said Uncle Robert.

"You've been telling so much about the river swinging from side to side," said Mr. Leonard, after a while, "that I've been wondering when our river is going to come back to this side and take away my cornfield. I fear I shouldn't like that."

"Oh, wouldn't that be dreadful!" said Susie.

"It would be good for Mr. Davis," said Mrs. Leonard, smiling.

"What do you say, boys?" asked Uncle Robert.

"I say we'll just have to take what comes," said Donald, shaking his head.

"I've been thinking about that," said Frank "and I worked it out this way," taking up his drawing-book again. "Please see if I am right, Uncle Robert."



Frank's sketch of his father's farm.

They all looked eagerly at Frank's drawing.

"You see here is the dam at the village," he said. "Of course the river can't swing from side to side there. The dam holds it in just one place, and the water flows over it evenly. I mean that the force is just as strong in one place as in another. Then it begins to make our curve and the current goes to Mr. Davis's side. Now it seems to me that if the dam

stays there the river will always flow as it does now, that the dam holds it in one direction until it gets around this curve, anyhow. Am I right, Uncle Robert?"

"I think you are," said Uncle Robert. "You have done well to work this out by yourself."

"Then my cornfield is safe," said Mr. Leonard, smiling.

"I wonder how it is farther down the river," said Donald.

"Suppose we take a trip down there sometime and see," said Uncle Robert. "How would you like that?"

"Oh, it would be great fun," said Frank.

"I could live in a boat on a river," said Donald.

Susie crept quietly to Uncle Robert's side and put her arms about his neck.

"Please, uncle, take me this time; I won't be any trouble."

"Yes, we'll take you too next time," said Uncle Robert. "A young lady who can describe the work of a glacier as well as you did the other day deserves to travel with the class in geography."

"That was because she had a good teacher," said Donald.

"When are we going, Uncle Robert?" asked Susie.

"We'll have to wait until next summer, I think; but this winter we will take some imaginary journeys along the Nile and other great rivers of the world, to see if they are like the smaller rivers we have seen."

"The work on the farm is so light in the winter time," said Mr. Leonard, "that I believe I will travel with you if you will let me."

"Yes, you can come too, father, if you'll promise to work out your own problems," said Frank, laughing.

"I don't want to be left alone at home," said Mrs. Leonard; "and besides I have always been interested in the stories of the Nile and Egypt."

"We will all travel together, then," said Uncle Robert, "and I foresee some pleasant winter evenings around the table finding out what the world is like in places that we may never see except in imagination."

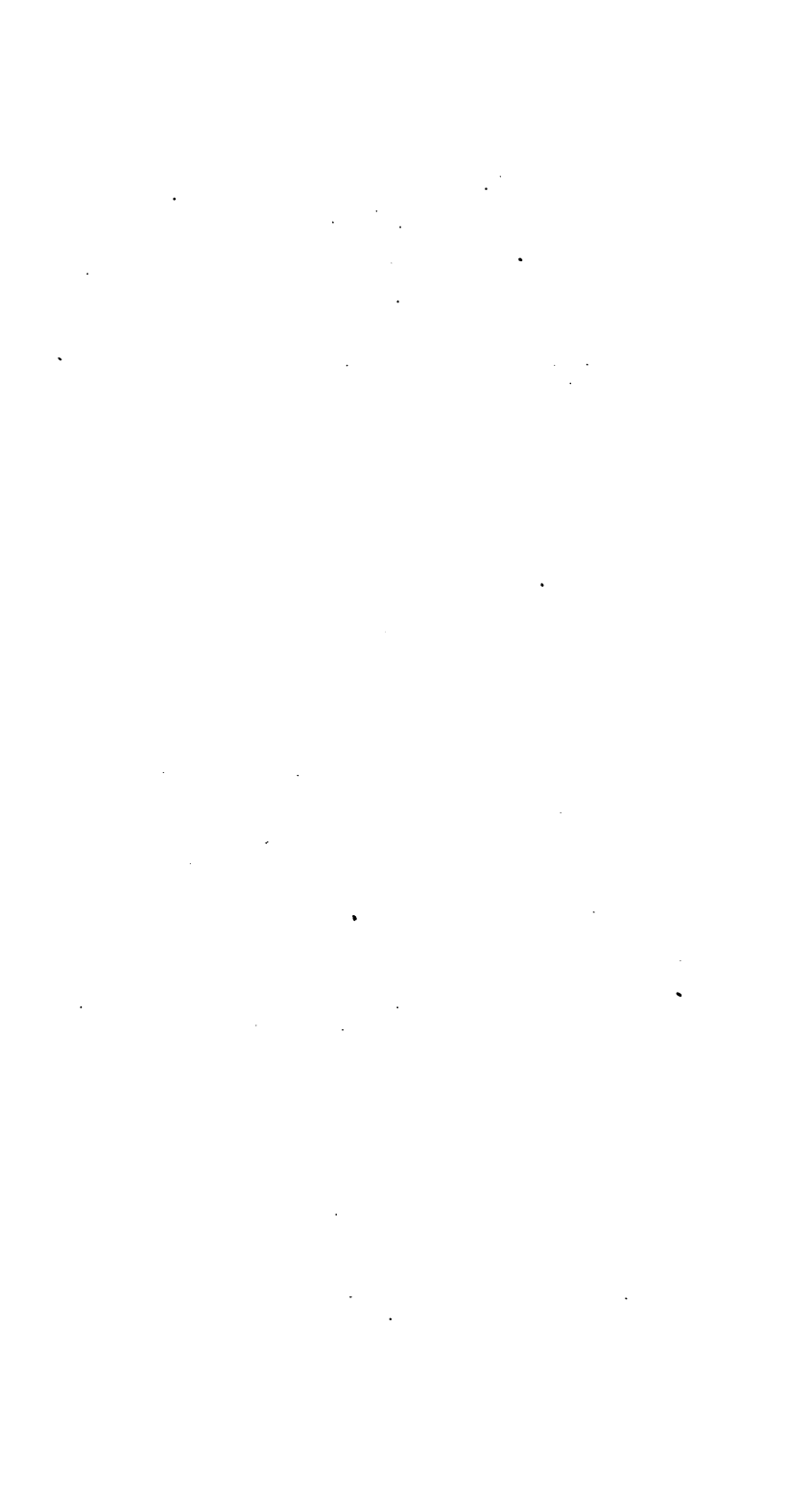
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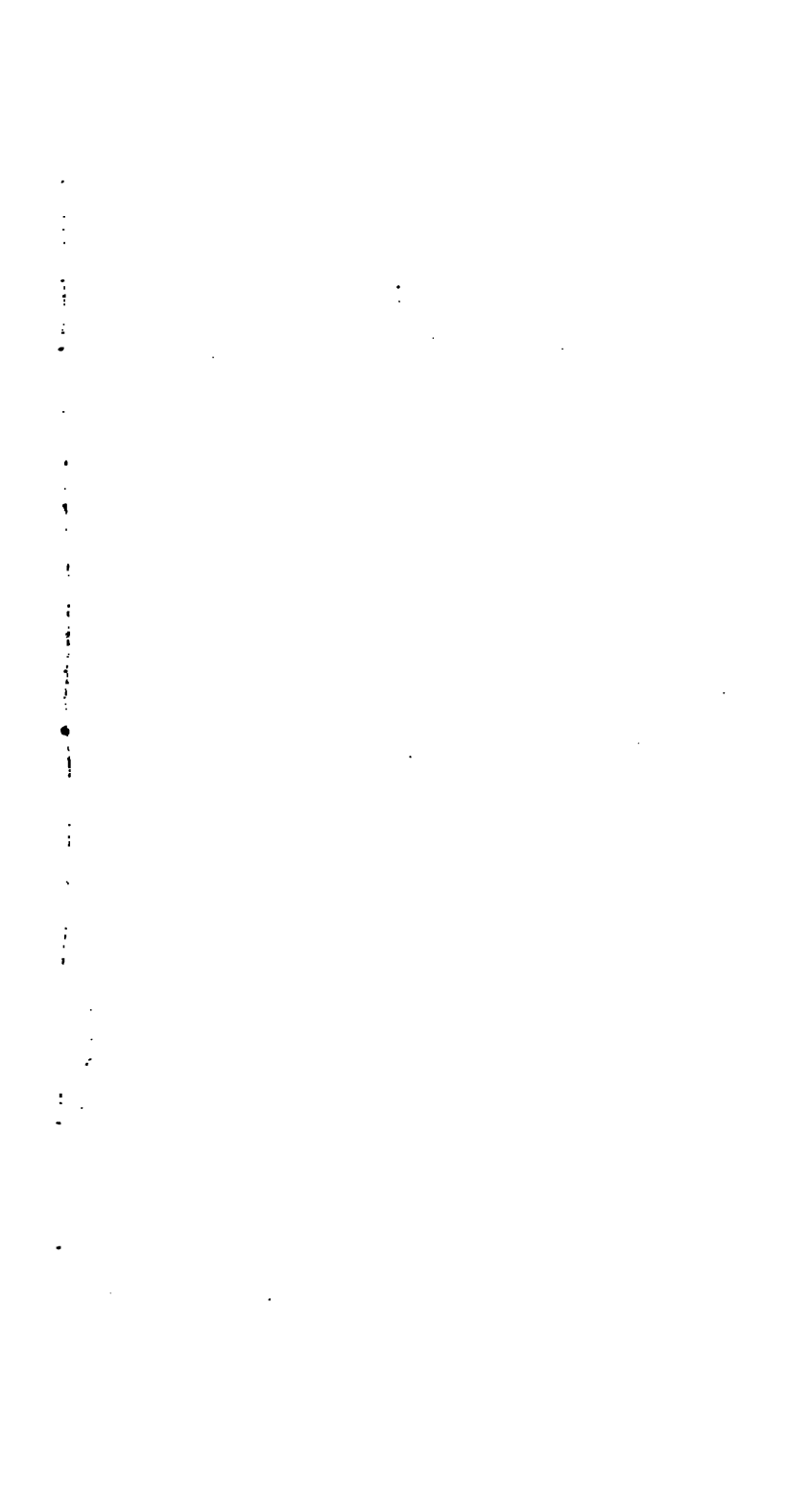
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